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The Three Years of Unparalleled Growth Back of Engineering-Contracting, and the Cause.

Although the title ENGINEERING-CONTRACTING was coined before it had absorbed Engineering World and Contract News, its two competitors, still the title indicates aptly the fusion of those two journals, the one for civil engineers and the other for contractors.

On Jan. 1, 1906, the present title of this journal, ENGINEERING-CONTRACTING, first appeared in print. A few months later, Contract News was purchased and consolidated with ENGINEERING CONTRACTING, at which time this journal assumed the volume number of Contract News. Hence it is that ENGINEERING-CONTRACTING now enters upon its sixteenth year, if regarded as the literary successor of Contract News, which it is only in so far as the contract news section of this paper is concerned.

Just 18 months ago Engineering World was purchased by ENGINEERING-CONTRACTING, and this consolidation gave ENGINEERING-CONTRACTING another strong impetus, particularly in the growth of its advertising pages.

Effective as these two purchases were in bringing ENGINEERING-CONTRACTING rapidly to the front, the real secret of its unparalleled growth in circulation is to be found in two causes, first the character of its articles, second the flood of sample copies that have been sent out continuously to bring these articles before engineers and contractors.

To those of our present readers who have not been acquainted long with our paper, a word or two as to its origin may be of interest.

At the time that ENGINEERING-CONTRACTING began its career, literature on the methods and cost of doing engineering construction work was exceedingly meagre. Yet costs are the only real criterion of efficiency in design and contruction. Other periodicals poohooed the idea that itemized costs could be of much value—they still poohoo them. Here evidently was a colossal ignorance, and a behind the-timesness which could be taken advantage of. The publishers of ENGINEERING CONTRACTING had just published Gillette's "Handbook of Cost Data," and its sale had knocked sky high all old fogied theories about the uselessness of cost data. Why not, therefore, produce a weekly periodical which would be a serial sequel of the "Handbook of Cost Data?" The thought was parent to the act within a few weeks after its conception.

Contractors who had ceased to read any technical paper, engineers who were planning to become contractors, and engineers who could see the advantage that accurrate knowledge of costs gives, not only in estimating but in designing structures, began to subscribe for ENGINEERING CONTRACTING. Here was a paper for the man engaged in managing men in construction work, and, due to the partial vacuum that had existed in this part of the publishing field, there was an inrush of subscriptions which we are satisfied has never been remotely approached before. In fact, we know that in three years our growth in circulation has been greater than that of one of our largest contemporaries has been in a quarter of a century.

One important aid in building up the circulation of ENGINEERING CONTRACTING was the sale of the methods and cost books published by the publishers of ENGINEERING-CONTRACTING. Our book purchasers now number many thousands of engineers and contractors whose names are on our card lists of book buyers. As quickly as a new book purchaser is secured, he receives a sample copy of ENGINEERING-CONTRACTING. Generally the result is a new subscription to the paper.

For two years ENGINEERING CONTRACTING confined its articles almost exclusively to methods and cost matter; but just a year ago the time seemed ripe to broaden the field considerably. So, in our first issue in January, 1908, we made a decided increase in the number of reading pages, and made several important additions to the paper. Among the most important of these additions was the feature of giving a brief review of every good article in every periodical published in the English language, provided only that the article reviewed was of interest to civil engineers or contractors. This feature appears in the present issue of ENGINEERING-CONTRACTING as it has appeared for the past 12 months, and it will be continued, for it has proved attractive and profitable to a host of readers.

We need not tell our old readers that we have been steadily strengthening and enlarging the paper until it covers the whole field of civil engineering and contracting. We have by no means ceased to grow, and there will be further enlargements during the current year.

At a time when many other publishers have been curtailing expenses ENGINEERING-CONTRACTING has been increasing its expenditures both by enlargements, as just indicated, and by a vigorous campaign of sample copy distribution to get more readers.

During the past year our readers have sent us the addresses of nearly 1,000 of their friends who are either contractors or engineers. To these addresses we have sent sample copies, thus adding more subscribers steadily through the kindness of our subscribers. We take this occasion to thank most heartily every reader who has sent us any names of his engineering or contracting friends.

A total of 1,371,827 fine ounces of gold, valued at $90,435,700, was produced in the United States in 1907.

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The Business Outlook For Engineers and Contractors.

Turning from an editorial of retrospect to one of prospect, we see a period of great prosperity for engineers and contractors beginning with the new year of 1909.

The railways of the country have cut all maintenance and betterment expenses to the bone during the past 15 months, and they are now forced by the very exigencies of the situation to "get busy." Railway tonnage and earnings are again normal. We should not forget that just prior to the panic all the railway lines of the country were so congested that James J. Hill, President of the Great Northern, said that $500,000,000 would have to be expended annually for many years by American railways to provide adequate facilities for handling the traffic.

The country has recovered from the 1907 panic in one-quarter the time required to recover from the panic of 1893, due to the fact that conditions were wholly different. In 1892 there was no congestion of freight. In fact, railway building had gone far ahead of the actual demand for transportation facilities. In the fore part of 1907 "car famines" existed everywhere. The "car famines" of many roads, however, were really track famines and terminal facilities famines. Practically all the railway trunk lines west of the Mississippi were then, and still are, single track lines, and their limit had been reached. It is a certainty, therefore, that the greatest decade of railway construction that the country has ever seen is now about to begin.

For every mile of railroad in America there are 10 miles of wagon roads and of these wagon roads not one mile in 10 is graveled, macadamized, oiled or otherwise improved. More than 2,000,000 miles of these highways await improvement, and it is safe to say that at least $3,000 a mile will be the average expenditure upon the improvement of these roads, or $6,000,000,000 in all. The sum is staggering, but when we remember that not a single unimproved road exists in England, we have precedent sufficient to convince us that America will not wallow in mud or stifle in dust many years longer. A great era of road building has already begun. Last year one firm of contractors alone had $2,000,000 worth of road work in New York state.

Two great forces have been at work bringing about this road building era, namely, the "state aid" laws passed within the last few years by most of the states, and the wonderful popularity of automobiles.

Automobiles, also, are responsible for having created a strong public sentiment for better street pavements. There are thousands of miles of unpaved streets in the towns and villages of America, to say nothing of the cities. In fact many a good state road ends at the city limits, and the street into which the road leads is a disgrace to the intelligence of those who reside upon it. Civic pride will not long permit the surface of streets to remain inferior to the good roads of the country outside the city or village.

It has taken a decade to educate the public up to a realization of the perils that infest poor drinking water. Now, few people drink water without thinking of microbes, if the water looks at all cloudy. Appropriations for filtration plants, new reservoirs, etc., are therefore secured with ease where they would formerly have been made to wait. Philadelphia, for example, waited for filtration plants for years, while thousands of people died of typhoid.

The country enters upon an era of constructing water works and sewage disposal plants, because the public has at last gained some knowledge of sanitary science and knows that great loss of life can be prevented by better attention both to the treatment of water before it reaches the consumer and afterward.

Not forgetful of the serious embarrassment occasioned by freight congestions a year and a half ago, manufacturers and mercantile houses of the middle states are making an aggressive fight for canals and canalization of rivers. A similar agitation in New York state a short time ago has led to the enormous work of virtually rebuilding the Erie Canal across that state at a cost of $100,000,000, a work that is now in progress. When one state, unaided by the government, will undertake a mammoth project of this sort, it shows that the attitude of business men is unmistakably in favor of improving our great waterways.

Those who have not been west have but little conception of the magnitude of the various irrigation projects now under way, to say nothing of the greater ones in contemplation and about to be carried out. The city of Los Angeles alone is spending about a quarter as much for a new water supply system as the state of New York is spending on its new canal. We mention Los Angeles in this connection, for the water that it is going to bring a hundred miles through aqueducts and canals is to be used largely for irrigation. Beside the large irrigation projects of the U. S. Reclamation Service, there are many private projects of enormous magnitude in the aggregate.

Clearly, then, there is to be more work for civil engineers and contractors than there has ever been before. Therefore, we may all look into the future with cheerful hearts and well may there be a ring of sincerity in every greeting that conveys a wish for a happy and a prosperous new year.

Silver to the amount of 56,514,700 fine ounces was produced in the United States in 1907. The commercial value was $37,299,700.

Remarks on Foreign Advertising.

There are now 60 members of the Technical Publicity Association, all of whom are Advertising Managers of firms engaged in the manufacture of machinery or supplies used in the operation of machines.

The president of the Association is Mr. Charles S. Redfield, Adv. Mgr., The Yale & Towne Mfg. Co., New York City.

At the twenty-first monthly meeting and dinner of the T. P. A., held in New York, Oct. 8, Mr. Redfield spoke on the subject of "Foreign Advertising." Mr. Redfield had just returned from a three months' trip to Europe, so that his conclusions are based upon a knowledge of conditions at first hand. We quote Mr. Redfield's remarks from the November issue of the T. P. A. Bulletin, in part:

"It seems that the trade papers of Europe can be most justly dealt with by giving them a good 'knocking'; but, on the other hand, there is an unwritten law somewhere that 'you should not "knock" or "kick" any one who is down'—and the trade papers of Europe may certainly be considered *'down,'* and more or less *'out.'*

"It is of course an old saying that where there is a demand there will be a supply, and the average business man in Europe will probably tell you that the poor quality of the supply is because there is little demand for good trade papers in the various industries.

"To my mind, however, a properly conducted trade paper produces its own demand, and then proceeds to fill it. Its mission is a *definite* one in America, and its place in the business world a *definite* place.

"The *Germans* have been called the 'Yankees' of Europe and I cannot express myself too strongly in commending their energy and wide-awakeness.

"Imitation of competitors' goods, and competitors' methods, is keen everywhere (certainly we are used to it in this country), but for slavish imitation of everything which promises to earn a dollar for the imitator Germany has the rest of the world 'skinned to death.'

"The respect of all the older countries for *American ideas* specially impressed me.

"That the trade paper performs absolutely necessary work *at home* is not a subject to question: that the trade papers in Europe will in time develop and become genuine influences for good in their several lines there is also no question—but it will be a matter of years.

"At present for any American manufacturer to attempt to use extensively the trade papers of Europe to push the sale of his product is, in my judgment, money very poorly invested; except as he may have some wise and careful agents in the various countries who are capable of taking and using a certain amount of trade paper space; watching it carefully; loading the paper with reading notices, and generally exercising that supervision which can only be given when close at hand."

To the editors of Engineering-Contracting it has long been apparent that the weakness of foreign trade papers may be traced to the fact that they are edited in the interest of the *designer* rather than in the interest of the *builder* of the structure or *user* of the machine designed. This is particularly noticeable in foreign papers that occupy our own field of civil engineering and contracting. . In all Europe there is not, so far as we know, a single engineering periodical that gives good, practical reading matter regularly on the *methods* of building engineering structures or operating engineering plants. As for *costs* of such building or operation—which are, after all, the final criterion of efficiency—no foreign paper ever has more than a meager word or two to say. Certain of the better foreign periodicals do have a good deal on the *design* of engineering structures and plants. Most profuse and detailed illustrations of the design of a battleship, or a dry dock, for example, will be frequently found in "Engineering" of London. For the engineer or contractor who is engaged in the actual work of building the ship on the dock, there is next to nothing in the articles. Yet the constructing engineer and the contractor are the men who do most of the ordering or purchasing of machines, materials and supplies. In default of a better paper they may subscribe for a mediocre periodical, but seldom read it. It cannot be impressed too strongly upon publishers and advertisers alike that the true test of the advertising value of a periodical is to be found in the *kind* of articles and news that it provides. If the *kind* is not right, then there may be thousands of "readers" but scarcely a single *reader* of the class that buys things advertised.

The Carnegie Institute, of Washington, D. C., is having constructed a special vessel for use in making an accurate magnetic survey of the ocean. The vessel will be 155 feet long, 33 feet beam and 12 feet draft and barkentine rigged. It will cost approximately $125,000. It will be primarily a sailing vessel, but will be equipped with auxiliary power to give a speed of six miles an hour. This power will be supplied by gas engines. The propelling engines, machinery and other metal parts of the craft will be chiefly bronze. Manganese metal and gunmetal will also be employed. Every bolt, nail, bar and brace in the vessel will be of these materials. The anchors also will be of bronze. There is some doubt as to whether the crank shaft in the engine can be constructed of this metal. If it should turn out that this piece must be of steel, it will be the only specimen of this metal employed on the entire vessel. The first voyage of the Carnegie will be to the north, visiting Hudson Bay and Greenland.

Concrete and Reinforced Concrete Section

Note: This Section is devoted to methods and costs of constructing concrete and reinforced concrete structures. It will cover the selection, testing and proportioning of concrete materials; laboratory tests of concrete; concrete mixing, transportation and placing; fabrication and placing of reinforcement, and form construction and erection. It will also contain articles on new and interesting developments in the design of reinforced concrete.

The Coming Annual Convention of the National Association of Cement Users.

The annual convention of the National Association of Cement Users will be held at Cleveland, O., on Jan. 11 to 16, 1909, with headquarters and meeting room at the Hotel Hollenden and exhibition hall at the Central Armory, about two blocks away. Judging from reports from members and from the program of papers and committee reports to be presented the convention should be one of the most successful in the history of the Association. The applications for exhibition space have been so numerous that the main floor and gallery of the armory are already taken up and space is being allotted in other parts of the building. This year the exhibits have been grouped and classified so as to afford better opportunity for study and comparison. Incidentally, it may be noted, four prizes of $50, $25, $15 and $10 will be awarded for the most attractive, effective and artistic arrangement of exhibits.

The program contains many titles of interest and the papers should be of exceeding interest and value if the promise of their titles is fulfilled by the presentation of real analyses of methods and costs. This program condensed is as follows:

Cost and Value of Concrete Roads, by J H. Chubb, Chicago, Ill.

Report of Committee on Streets, Sidewalks and Floors, by W W. Schouler, Chairman, Newark, N. J., presenting (a) Revision in Standard Specifications for Sidewalks: (b) Proposed Standard Specifications for Concrete Roads

Annual Address by the President, Mr. Richard L. Humphrey, Consulting Engineer, Philadelphia, Pa.

Cost of Reinforced Concrete Construction as Applied to Buildings, by Leonard C. Wason, President, Aberthaw Construction Co., Boston, Mass.

Comparative Cost of Reinforced Concrete Buildings, by Emile G Perrot, of Ballinger & Perrot, Architects, Philadelphia, Pa

The Availability of Concrete for Bridges—Its Cost and Durability, by H. H. Quimby, Engineer of Bridges, Philadelphia, Pa

Cost of Reinforced Concrete Construction as Applied to Bridges, by E P Goodrich, Consulting Engineer, New York, N. Y.

Report of Committee on Testing Concrete and Cement Products, by F S. Larned, Chairman, Boston, Mass

Report of Committee on Cement Products and Machinery, by A T Bradley, Chairman, Rochester, N Y.

Report of Committee on Art and Architecture, by Charles D. Watson, Chairman, Pittsburg, Pa.

Decorative Concrete Stone, by F. A Norris, Boston, Mass.

Reinforced Concrete Residences, by B A Howes, Jr, New York, N. Y.

Small Concrete Houses—Manufacture and Cost, by R C. Knapp, Philadelphia, Pa

Monolithic Concrete Wall Buildings—Methods, Construction and Cost, by Col Robert H Aiken, Chicago, Ill.

Methods and Cost of Surface Finishes for Concrete.

Advantages of Reinforced Concrete for Railroad Construction, by B H Davis, Assistant Engineer, D. L. & W R R, Hoboken, N. J

Cold Storage Warehouses of Reinforced Concrete Construction, by J. P. H. Perry, Turner Construction Co., New York, N. Y.

The Applicability and Comparative Cost of Concrete and Reinforced Concrete for Subway Construction, by Charles M Mills, Assistant Engineer, Philadelphia Rapid Transit Co., Philadelphia, Pa.

Value and Cost of Reinforced Concrete for Retaining Walls, by A. Lindau, Corrugated Bar Co, St Louis, Mo.

Methods and Economy of Assembling Reinforcement as Units Before Placing in Reinforced Concrete Construction, by H F Porter, Philadelphia, Pa

Report of Committee on Insurance, Laws and Ordinances, by W H Ham, Chairman New York, N Y

Methods of Attaching Shafting and Machinery in Reinforced Concrete Buildings, by Wm M Bailey, Chief Engineer, Eastern Concrete Construction Co., Boston, Mass

Value and Cost of Cement Inspection

Cost of Concrete Telegraph Poles

Cost of Waterproofing

Cost of Concrete Piles

Value and Cost of Steam Curing of Concrete Blocks, by F S Phipps, Manager, Central Stone Co, St Joseph, Mo

Use and Cost of Cement Tile for Fireproofing Purposes.

The Present and Future of the Cement Block—Its Cost, Manufacture and Availability, by J. Augustine Smith, Ideal Concrete Machinery Co, South Bend, Ind.

Method of Finishing Concrete Surfaces by Scrubbing Followed by an Acid Wash, With an Estimate of Cost.

The accompanying views show concrete surface finishes produced by scrubbing, followed by etching with acid. As will be seen the scrubbing and acid wash remove the cement surface to a depth which leaves the aggregates partially exposed. Ordinarily where a particularly uniform surface, or one of some particular tint is wished a surface facing 1 to 2 ins. thick of special mixture is employed, but the ordinary concrete mixture can be so scrubbed and etched if desired. A very brief inspection of the finishes illustrated makes it clear that attractive concrete surfaces are possible if one cares to take the pains to secure them.

The surfaces illustrated were photographed from laboratory specimens, and doubtless exhibit a nicer appearance in detail than would be common in actual construction, but the same method of finish has been employed in actual construction and very excellent results secured. The materials used for the finishes illustrated were not selected with greater care than is quite possible in actual construction. For the surface shown by Fig. 1 a 1-3 sand mixture was employed; the sand all passed a No. 8 and was retained in a No. 50 sieve. For the surface shown by Fig. 2 a 1-3 mixture was also used, the sand, however, being coarse, it all passing a No. 4 and stopping on a No. 8 sieve. The surface shown by Fig. 3 consisted of a 1-3 mixture of ¼ to ½-in. pebbles. Except in the size of aggregate, all these three surfaces are identical, yet the variation in surface appearance is most striking. These are natural sand and pebble surfaces, no selection of aggregate beyond screening being resorted to. Figures 4 and 5 show results with an artificial aggregate—a crushed red granite. A 1-2½ mixture was used in both cases, but in Fig. 4 the material was screened to pass a No. 8 and to stay on a No. 16 sieve, while in Fig. 5 regular commercial granite screenings not passing a No. 8 sieve was used as it came. The variation in texture is evident; in addition it is important to note that the actual surfaces have a tint or color, not shown by the engraving, due to the red granite aggregate. In the same way other tints than red can be obtained by selecting other colors of stone for the aggregate. Thus in Fig. 2 the pebbles are black, while the cement binding them has the usual greyish tint. In this finish the pebbles ranged up to 1¼ ins in size and were screened from, all material passing a No. 10 sieve. It is not essential, of course, that pebbles of one color be selected; the regular mixture coming from the bank would do as well and by many would perhaps be preferred. In short, it is evident that the variation in texture and color of finish indicated by these views is almost without limit, except, of course, no limestone aggregates will stand the acid treatment.

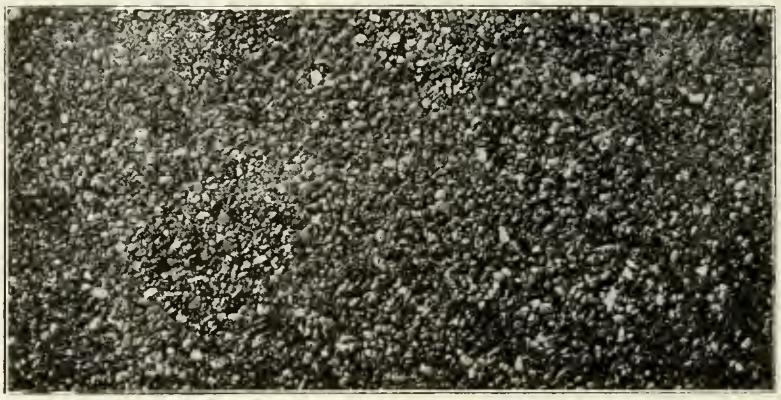


Fig. 1—Scrubbed and Etched Surface of 1-3 Fine Sand Mortar.

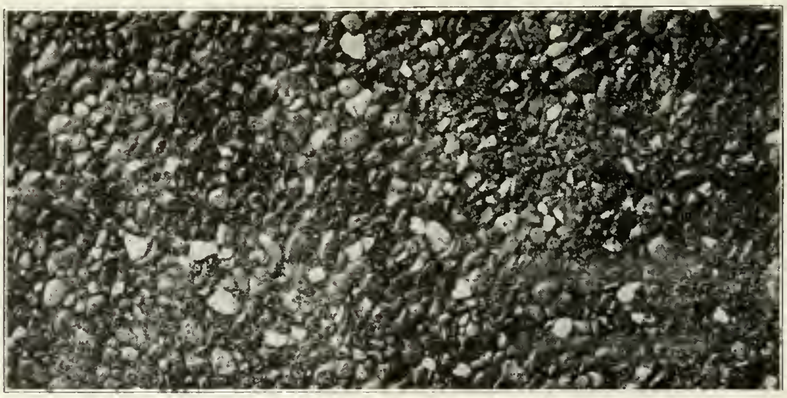


Fig. 2—Scrubbed and Etched Surface of 1-3 Coarse Sand Mortar.

The method of treatment may be briefly described as follows: While the concrete is still green, the forms are removed and the surface is scrubbed with an ordinary scrubbing brush having stiff palmetto fibres or a wire brush may be used. This brushing should lay bare the aggregate and remove enough of the cement between the particles to let them project slightly, but not enough to make their adhesion to the mass insecure. Two or three days after brushing apply with an ordinary calcimining brush a hydrochloric acid solution composed of 1 part commercial hydrochloric acid and 2 parts water. This acid solution should be left to "work" about 30 minutes, and while "working" the wall should be rubbed with a very stiff vegetable fiber brush. As fast as the etching and scrubbing is completed, which result must be determined by the judgment of the workman, the acid should be washed off with a hose. The washing must be thorough, with plenty of water, otherwise the sediment will give a blotchy and streaky appearance to the surface.

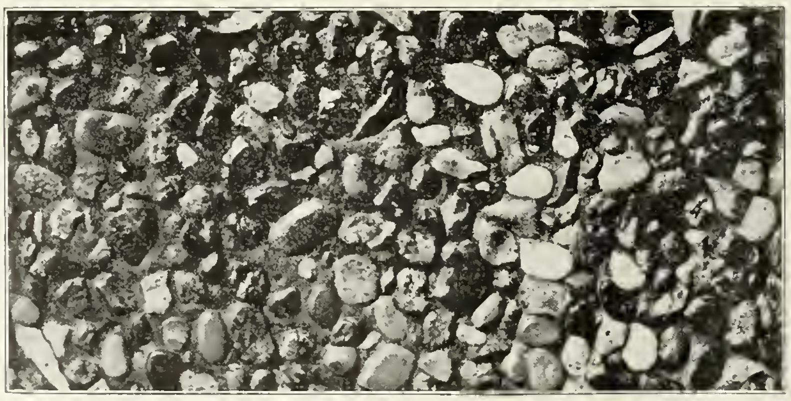


Fig. 3—Scrubbed and Etched Surface of 1-3 Small Pebble Mixture.

Judgment is required in doing the etching and washing if the best results are to be secured. Judgment is also necessary in performing the preliminary scrubbing, since the cement must be hard enough to hold the aggregate firmly, and still soft enough to be readily removed by the brush without excessive labor. No set time for removing the forms can be given. In hot weather the forms can, as a rule, be removed the day after the concrete is placed, say, in 24 hours, but in cold weather the period may be from two days to a week. The contractor must determine the proper time for himself in each case. In this connection it is important to keep in mind that uniformity in time of setting and in results obtained will be increased by adhering to a uniform surface mixture, that is, using always the same brand of cement, the same proportions and the same sizes of aggregate. Once the mixture required to get the desired effect is determined it should be invariably adhered to. This is a detail which is often neglected and always gives trouble when neglected.

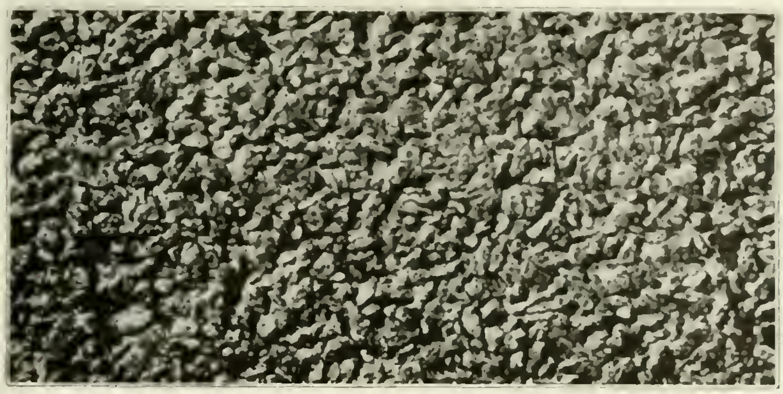


Fig. 4—Scrubbed and Etched Surface of 1-2½ Mixture of Fine Granite Screenings.

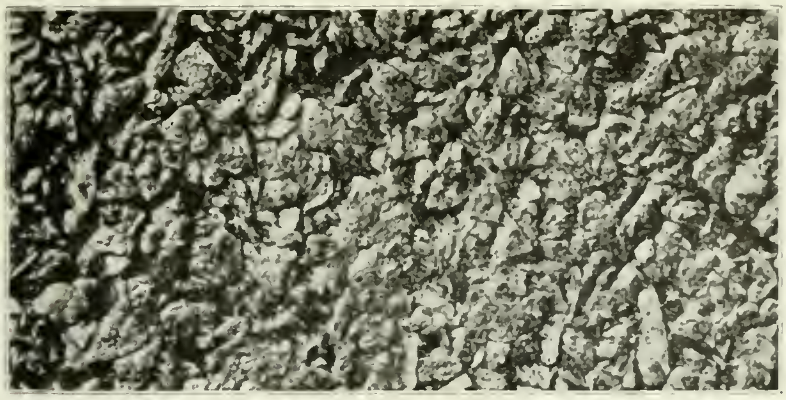


Fig. 5—Scrubbed and Etched Surface of 1-2½ Mixture Coarse Granite Screenings.

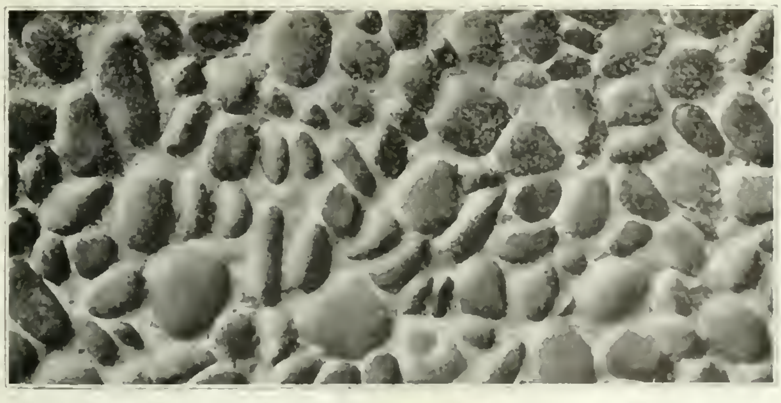


Fig. 6—Scrubbed and Etched Surface of 1-2½ Mixture of Coarse Pebbles.

Finishing by scrubbing the green concrete means that the forms must be readily removable. This requirement may be met by setting the studding back a few inches and using cleats and short struts to hold the lagging in place; removing the struts and cleats permits the lagging to be stripped off without taking down the studs, which may be required to hold the lagging above where concreting is being done. The lagging used should be of even thickness and have good joints, but it need not have a particularly fine finish. The lagging must be well oiled, since it has to be stripped while the concrete is comparatively soft and the adhesion, will tear out pieces of the green material. Ordinary joint marks and roughness are obliterated by the finishing treatment, but deep welts and cavities are not, so that the impression that very rough and crude form work will do when the scrubbed and acid finishes are used, is erroneous.

The placing of the surface mixture is another feature of this method of finishing that may not be neglected. The facing material should be from 1 to 1½ ins. thick, the remaining thickness of the work being composed of ordinary concrete, but the facing and backing must be deposited at the same time so as to make one solid mass thereby ensuring perfect bond. The facing material may be applied to the boards just ahead of the backing which is placed against and rammed into it, or the backing may be placed first and then pushed back from the form with a spade and the facing material deposited between the backing and the form. Both these methods have been successfully used. A third, and possibly the best method of placing the facing material, consists of the use of what might be called a metal facing form or mold, constructed and used as follows: To 3-16 in. iron plates 8 or 10 ins wide and 6 ft. long, three 1 or 1½ in. angles are riveted, placing an angle at the center of the plate, and one about 6 ins from each end. One edge of the plate should be slightly flared to assist in depositing the material and this edge provided with handles. The metal facing plate is placed against the wall form with the handles up and the angles tight against the form. The space between it and the back of the wall is filled with the concrete backing and the 1 or 1½-in. space between the metal form and the face form is filled with the facing material. The metal form is drawn almost out and after thoroughly tamping the backing against the facing the process is repeated.

The method of finishing concrete surfaces which has been described is a combination of the scrubbed finish used for some years in Philadelphia, Pa., in all concrete work requiring special treatment, and of the acid wash finish so extensively used in the concrete work of the Chicago South Park Commission. It has been worked out in the laboratories of the Universal Portland Cement Co., of Chicago, and the engravings shown here are from photographs of laboratory specimens. We are indebted to this company for the use of these photographs.

In studying the special concrete finish described, the question naturally arises as to what its cost will be. No figures of cost were worked out by the laboratory engineers of the above company and none have yet been gotten from contractors who have used it. We may, however, come to some idea of the cost by analysis. It is clear that such costs will be made up of two items: (1) the extra cost of the special mixture used for the surface coating, and (2) the labor and materials, cost of doing the scrubbing and etching. The first item is one that may be quite easily computed when the local prices of materials are known. Regarding the cost of scrubbing, experience in Philadelphia, covering a large amount of work, shows that it depends largely on the hardness of the concrete. When the concrete is just right for the most effective work an active man will scrub 100 sq. ft. per hour;* with wages at 20 cts. per hour, this gives a labor cost of 0.2 ct. per sq. ft. In our issue of Dec. 9, 1908, itemized costs were given for the acid wash treatment of 29,395 sq. ft. of sidewalk surface; the cost was 1⅔ cts. per sq. ft., including acid, brushes, labor and 10 per cent for superintendence. Figuring from these data, the cost of the concrete finish described should fall between 2 cts. and 3 cts. per sq. ft., for treatment alone. To this must be added the excess cost of special facing mixture over ordinary concrete and probably something extra for form work.

A New Tilting Mixer With Some Novel Construction Details.

The accompanying illustration shows a concrete mixer which has several distinctive constructional features. The drum is all cast-iron, is machined perfectly true, and is flanged to protect the track wheels from slopping or flying materials. The ends of the drum are dished outward or convexed to project the materials toward the center and prevent slopping. Each opening is also closed against slopping by a special collar shield. All interior surfaces, including blades and buckets, are designed with liberal curves to prevent clogging of materials. The mixing blades are also raised from the surface of the drum to allow for passage of the cleansing water. There are no bolts or rivets on the inside of the drum.

Mixing is effected "by means of a swirling motion, caused by the specially inclined flights and elevator buckets facilitated by what may be described as a cascade action from the shield of the discharge spout." The machine will discharge any quantity required. The discharge spout is stationary and connects with the interior by means of a tilting shield. The discharge lever can be operated by the barrow men.

The main drive consists of a sprocket-tooth ring at the middle of the drum, and a "steel thimble roller chain belt," with case-hardened bushings and pins. This drive is claimed to require less power than any combination of gears. Steam, gasoline or electric power may be employed. The rack wheels are made of a special mixture of iron cast in ring chills, similar to car wheels, with faces ground absolutely true.

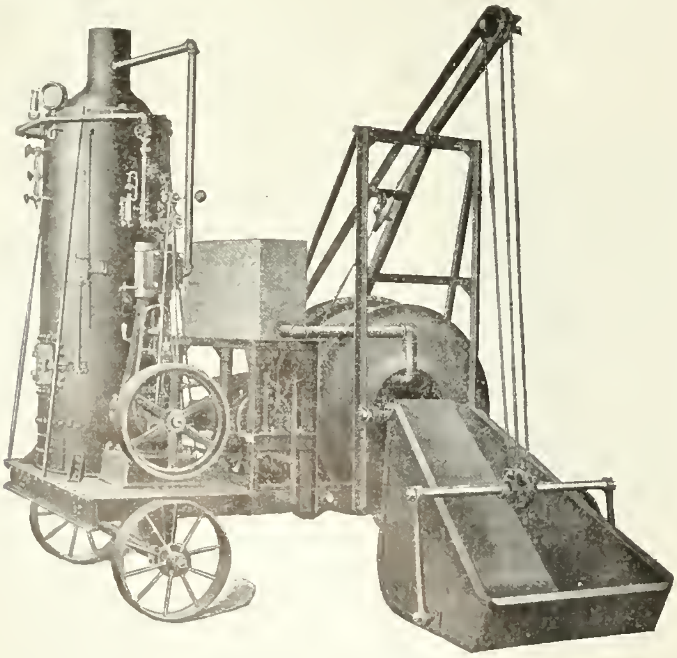
The frame is short and wide, giving a broad base with great rigidity to the machine and insuring steadiness of operation under all conditions of service in the field. It also is of all steel construction. Steel compression cups for lubricating grease are provided for all wearing parts, and each of these cups can be adjusted while the machine is in operation.

A standard hopper or superhopper, the latter holding the full batch, is furnished when required. The superhopper is designed for use wherever the material can be conveniently charged in full batches from a higher level. A special feature of this mixer is the power loader of steel construction, which is filled at ground level, from barrows or otherwise, and holds the full batch, thus doing away with the construction of a raised platform and runway necessary where the ordinary standard hopper is used. This loader is raised and lowered by means of wire cable and a grooved pulley suspended from a steel arm extending above the machine, and the mechanism is operated by a simple friction hoist thrown into action by a lever. Water from an adjustably regulated supply tank is drawn into the drum as the loader is discharged, bringing all the contents of the batch into position to be mixed without loss of time. By the use of this power loader a large saving in the cost of operation can be effected and the output materially increased.

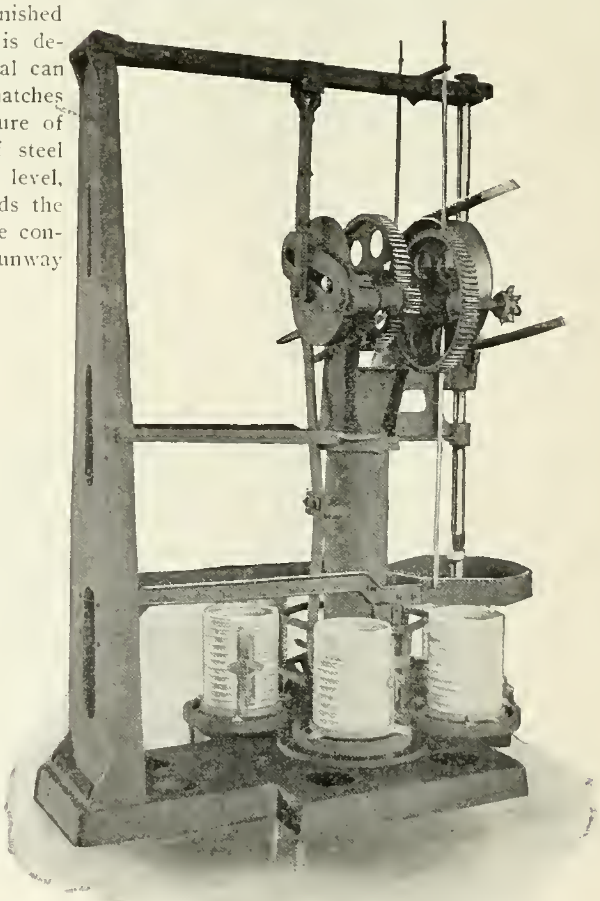
The mixer described is made by the Chain Belt Co., Milwaukee, Wis.

An Automatic Molding Machine for Cement Tile.

The growing favor with which cement or concrete tile are meeting in farm drainage work has led to a number of inventions of tile molding machines which would operate as nearly as practicable automatically. In the accompanying cut we illustrate one of the most substantially constructed of these molding machines. This machine is automatic. With a continuous mixer, the only hand labor required is shoveling the sand and cement into the mixer, and taking the casing off the finished tile, placing them on tracks to be set away to be cured, and replacing



A New Tilting Mixer.



Automatic Cement-Tile Molding Machine.

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*"Concrete Construction — Methods and Cost." By Gillette and Hill.

the empty casing back onto the tile machine, to repeat the process. The machine does all the rest of the work.

The ladder like arrangement at the side, carrying endless chains with two bucket-conveyors, is the device for elevating the exact quantity for one tile of freshly mixed concrete. This is dumped at the right moment, falling into an empty casing, as the packing device starts building or packing it up into the shape of a tile. The various cylinders shown are casings of metal which give form to the outside of the tile, being contracted and held in place by a lock device, and upon being loosed, allow the casings to expand, and release the finished tile.

To those who are familiar with machine tools the construction may be made fairly clear by saying that the tile machine is built something on the order of a modern drill-press, with a central column resting on a solid cast-iron base, and a revolving spindle in place and operating the packer. Around this central column is a circular frame for holding six casings, which form one set for any size tile, 4 to 12 ins. This frame is moved automatically, advancing step by step around the circle as the various casings are brought into the operation with the packer.

The device that packs the freshly mixed concrete into a thin cylinder (or tile) consists of two distinct mechanical parts that co-operate. The first is a revolving spindle holding two cylindrical packers that by their centrifugal motion move the soft concrete outward against the casing and presses, or packs it into a firm tile which can be handled readily without injury. The packer packs the concrete against the casing, beginning at the bottom of the casing, gradually receding upward, while a revolving core, the exact size of the tile, trowels the inside smooth. The whole machine is made rigid and strong.

This tile molding machine is known as the Miracle-Baldwin Cement Tile Machine and is manufactured by the Miracle Pressed Stone Co., Minneapolis, Minn.

The steam shovels of the Pacific Division of the Isthmian Canal excavated 115,553 cu. yds. from the Canal prism during November. The best record for the month was made by Shovel No. 222 working at Pedro Miguel Locks, which excavated 5,328 cu. yds. of earth and 21,312 cu. yds. of rock in the 23 working days. The best daily record was also made by Shovel No. 222, which on Nov. 18 excavated 2,079 cu. yds. of rock and earth.

In his annual report the Secretary of Interior states that over 350,000 acres of land have been placed under irrigation by the United States Reclamation Service since 1903, and that the projects approved amount to hundreds of thousands acres additional.

Earth and Rock Section

Note: This Section is devoted to methods and costs of excavating earth and rock and building embankments. It will cover the grading of roads and railroads, diking and canal work, dredging, building reservoirs and earth dams, sewer and water pipe trenching, quarrying, etc.

Methods and Costs of Rock Excavation and Washing Gravel for a Concrete Dam.

BY WM. C. STEELE.[†]

The work described in this article was done in connection with the building of a hollow concrete-steel dam of the Ambursen type for the Big Horn River Co., on the Big Horn River, at the entrance to a narrow canyon, about 20 miles from Shosone, Wyo.

The widening of the canyon and excavation for foundation necessitated the removal of a slice from the east face of the cliff of 1,500 cu. yds. of diorite—one of the hardest of rocks. This was somewhat more than was necessary for the actual design of the dam, but it was necessary to back to a slip. The bottom excavation was partly solid diorite, partly loose boulders of all sizes, and sand and gravel—a somewhat difficult combination to handle. It amounted to about 3,500 cu. yds.

A trestle was run from the east bank of the river to a portion of the dam on the west side, completed last year under other management. The material was loaded into one yard skips and dumped by a double down-swing gear derrick, through a double hopper, located on the west end of the trestle, into 1½ cu. yd. side dumpers, and hauled across by a single horse to the dump. The haul approximated 400 ft. Thus one car was in place for loading under one hopper while another was being hauled to the dump and back. The trestle is 150 ft. in length and for most of its length 35 ft in height. It is designed for a concentrated load of 5 tons, as it will be used for the transportation of machinery. It cost $236 for labor and materials. Some salvage lumber was used in its construction.

Another derrick, located on the east bank of the river, dumped into a hopper on the north end of the dump itself, and the cars were pushed by hand to the dump. The hoppers were roughly made of cottonwood logs, braced by 2x6 in braces, and were designed to save wear and tear on the cars, which would be occasioned by the landing of the skips directly on the cars, they also gave a larger margin of area upon which to land skips. The level of the dump was about 50 ft above excavation.

Five laborers attended to the disposal of material from both derricks, the horse and the dump, which had to be somewhat carefully run on account of space restrictions.

The track is 2 ft. gage and stub switches are used.

In Gillette's "Rock Excavation—Methods and Costs" it is stated, "wages were high," in speaking of paying $3 per drillers (machine). The following wages were paid per day of 10 hours. The dam was built in a mining country with an established rate of 50 cts. per hour for machine men; it is impossible to get them for less, and men brought from outside immediately demand the local rate.

	Per day 10 hours.
Machine drillers	$ 5.00
Derrick runners	5.00
Blacksmiths	5.00
Carpenters	4.00—5.00
Foremen	5.00—6.00
White labor	3.00—3.50
Bulgarian labor	2.00

Coal cost $16 per ton on the work. There is no wood to be had in this locality. Cement cost $1.10 per sack, or $1.40 per bbl., and all freight cost 40 cts. per 100 lbs. to haul from Shoshone to the work.

The following is an analysis of the cost of rock excavation for November, 190[illegible]. This excavation was practically all diorite.

	Per cu. yd.
Foremen	$0.038
Derrick runners and signalmen	0.078
Drilling, loading and firing shots	0.114
Mucking, loading and dumping cars	0.18
Repairs and maintenance of plant and equipment, labor	0.043
Repairs and maintenance of plant and equipment, supplies	0.018
Powder, caps, fuse and exploders	0.035
Powder	0.268
Proportion blacksmith shop, sharpening picks and drills, misc.	0.045
Proportion superintendence and time keeping	0.031
Total	$[illegible]

Last year the problem of aggregate for concrete presented serious difficulties. No satisfactory sand was to be found. The sand to be obtained is a fine quicksand, utterly unsuitable for concrete. The aggregate for the concrete was crushed diorite and sand made from the same by the regulation sand rolls. The cost was prohibitive. The extreme hardness and toughness of the diorite making the cost of crusher jaws alone average $10 for every 24 hours run.

This year a natural gravel deposit was discovered nearby, which contains an almost ideal mixture of graduated sizes. It was found, however, that it also contained a considerable percentage of loamy clay, which must be washed out. For this purpose a rotary washer was designed by Mr.

[†] Shoshone, Wyoming.

F. W. Hart, Chief Engineer of the Big Horn Power Co., and the same placed on a hillside below the road leading from the gravel pit. Below the washer a large storage bin was built. Water was supplied by a 4-in. centrifugal pump, located at the river bank below.

The operation was as follows: The gravel was loaded into carts and hauled to the washer, where it was dumped directly into the hopper of the washer, discharging into the large bin below. When the pile grew larger and spread a mine car of 1 ton capacity was installed and the track for same thrown or extended as it became necessary. The car for loading ran directly under the discharge of the washer. A small hopper fitted with a sliding door held the material during the time the car was out dumping. Two men attended to the dumping of carts and feeding the washer; two handled and dumped the car; one loaded and dumped the tailings (pebbles over 2 in.), and there was one man attending to the track, trimming dump and assisting generally.

The cost per yard was as follows:

	Per cu. yd.
Foremen	$0.039
Engineers and firemen	0.042
Loading carts	0.185
Haul (cart and driver)	0.128
Feeding washer	0.037
Handling and dumping car	0.047
Handling and dumping tailings	0.031
Repairs and maintenance of plant and equipment, labor	0.04
Repairs and maintenance of plant and equipment, supplies	0.017
Interpreter	0.029
Power	0.25
Proportion of superintendence and timekeeping	0.034
Total	$0.879

The cost of both the rock excavation and washing gravel include every possible charge, except the proportion of general expense (Chief Engineer and office) and interest and depreciation of plant.

To add to the difficulty of construction here, on account of the height of the river at other seasons, it is necessary that the work be done in the winter, in a temperature ranging from freezing to 20° or 30° below zero.

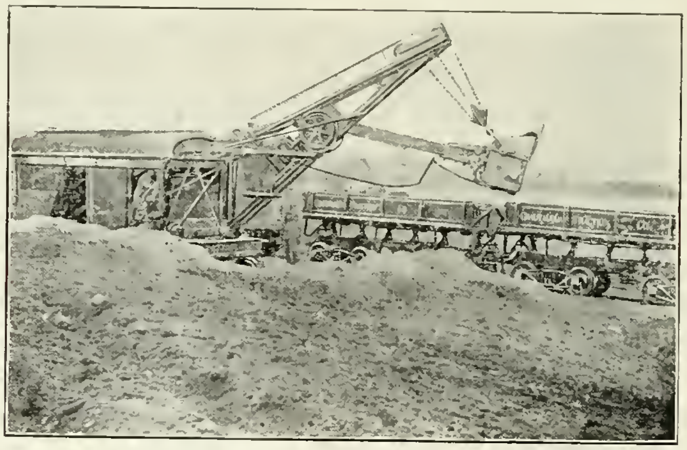
The forests of the United States now cover about 550 million acres, or about one-fourth of the land of the whole country. The original forests covered not less than 850 million acres, or nearly one-half The forests owned by the government cover one-fourth of the total forest area, and contain one-fifth of all timber standing.

There were actually employed on the Isthmian Canal work on Nov. 30, 23,964 persons. Of this number 4,151 were "gold" employes and 19,803 were "silver."

The Equipment of an Electric Power Shovel, Together with Some Cost Records.

For quite a number of years, power shovels operated by electricity have been in successful operation in different sections of the country, for such work as digging ballast for electric railways, dry placer gold mining, etc., but until recently no accurate records of the cost of work done by such shovels has been attainable. We are, however, able to present herewith some accurate records of work done by one of these shovels for the Chautauqua Traction Co., Jamestown, N. Y. This company is using the shovel for digging ballast for their road.

The shovel complete weighs about 40 tons. The car body is 27 ft. long by 6 ft. 8 ins. wide and is mounted on standard railroad wheels. It is equipped with 1½ cu. yd. dipper, which has a clear height of lift with door open of 12 ft. It will make a cut at level of rails of 26 ft. and will dump out 21 ft. 6 ins. either way from the center of the shovel. It is equipped with three separate motors, one for hoisting the dipper, one for swinging the crane, and a motor on the crane for crowding the dipper into the bank. All motors are of the regular railway type, variable speed, D. C., 600 volts, 700 R. P. M.



Steam Shovel Equipped for Operation by Electric Power.

One of the principal objections to an electrically operated shovel, made by people not familiar with their construction and equipment, is that in hoisting the dipper through the material it will frequently strike hard material which would stall the motor and burn it out, or on the other hand if the motor were of a size to have sufficient strength to stand such strains without burning out, it would tear the dipper to pieces and would ultimately reduce the entire machine to wreckage. The following shows how this objection is met and overcome in the construction of the shovel described above. The main or hoisting motor is 75 HP. and is provided with an automatic magnetic controller, and a circuit breaker which will throw off the current as soon as the motor has exerted its maximum safety power, thus preventing any harm to the motor. The important feature, however, is the series overload relay with which each motor is also equipped, and which is to the motor what a governor is to a steam engine. As soon as the dipper meets any obstruction in the shape of hard material or boulders, which would have a tendency to stall the motor, this overload relay automatically relieves the motor of the excess current and prevents it being overloaded or burned out, no matter what the conditions of service are.

Another objection to the electric shovel is in connection with the swinging motor, as when the crane or boom of any shovel is being swung it acquires a momentum which, if not checked in some way, causes it to drift around too far, making it liable to do considerable damage to the structural part of the shovel. On a steam shovel this drifting motion is counteracted by slightly reversing the engines. The steam acts as a cushion and allows the crane to swing around easily for the last few feet of the swing, when a little more steam admitted stops it altogether. On the electric shovel this momentum is taken care of by the solenoid brake, the clutch of which is thrown in by springs. When the current is turned on the swing motor, it is automatically turned on to the mechanism of the brake also, and forms a magnet which throws back the springs. Thus as soon as the power is applied to the swing motor a magnet is formed which releases the brake so that the swing of the crane is free to respond to the motor. As soon as the current is cut off, it of course cuts off the magnet and the springs are free to throw on the brake, which absorbs the shock of the momentum, bringing the crane to an easy stop at any desired point, and without any reverse power being exerted by the motor. The swinging motor is 30 HP. and is also safeguarded with a circuit breaker.

The crowding or crane motor is 30 HP. and is provided with automatic controller, circuit breaker, overload relay, etc., and is safeguarded much in the same manner as the hoisting motor. In addition to this, however, it is provided with a foot brake which is operated by the cranesman so that even should the circuit breaker be automatically thrown out, as the result of overloads or other causes, the foot brake is still capable of holding the dipper at any point desired. It will readily be seen from the above description of the electrical equipment that the electrically operated power shovel is in every way as safe and its action as easily controlled as a steam shovel. This shovel was built by the Vulcan Steam Shovel Co., of Toledo, Ohio.

Mr. A. N. Broadhead, president of the road, writes as follows as to the cost of the work: "A short time ago we placed an ammeter and volt-meter on the shovel for the purpose of ascertaining cost of operation per hour and hand you the inclosed memorandum. Of course, the shovel did not work constantly during this time, owing to the shortage of cars. If we had been able to keep the shovel at work without a let-up, we feel sure the cost per hour would be materially reduced."

	Cost of Power and Help.
1 man	$0.33
1 man	0.25
2 men, at 15 cents	0.30
20,346 K. W. hrs. at .0088 cts	0.18
Oil and waste (estimated)	0.04
Total cost, per hour	$1.10

The amount excavated each hour was 66⅔ cu. yds., giving the following costs per day:

8 hours, at $1.10, $8.80.

8 hours, at 66⅔ cu. yds., 534 cu. yds.

$8.80 divided by 534 cu. yds., 1.64 cts per cu. yd. for loading.

The material excavated was a mixture of gravel, sticky clay and sand, which made it hard to dig, but as will be seen from the above figures, the cost of this work was very low. There are, of course, several causes for this, the principal ones being, first, that as the shovel requires no boiler, the cost of a fireman and of hauling coal and water are eliminated; second, that the work of the shovel was so intermittent and when the shovel was idle no power was being consumed as would be the case with steam shovel, where they must keep the steam up just the same. The shovel could have been operated to its maximum capacity, which would have given twice the yardage, at nearly the same cost as the men had to be paid whether they were working or idle, and the additional cost for power would not have been more than twice what it was which, on the same basis, would mean 1,068 yards at a cost of $10.24, or less than 1 ct. per cu. yd.

President Roosevelt has called an international conservation conference to meet in Washington on Feb. 18. Invitations have been sent to the Governments of Mexico and Canada.

Record of Drilling Test Holes by Hand with Some Costs.

In sinking test holes both for prospecting for minerals and also for civil engineering projects, the majority of the drilling is done with some kind of a power drill. Hand drills are sometimes used, but they are generally improvised in some blacksmith shop. Of late years a great many costs have been published on power drills of various kinds, but cost data on hand drilling have been meagre. In this article we are able to give the detail work of a hand drill used for prospecting in Colombia, South America. The drill was an Empire Hand Drill, manufactured by the New York Engineering Co. of New York. The work was done under the direction of Mr. Clarence R. Snow, during the autumn of 1908.

The work was done with native peons or Indians, who had never seen machinery of any kind before. The country in which the holes were being sunk was covered with forest, the bush and undergrowth in many places being very heavy. To move the drill from hole to hole a narrow path was cut through the undergrowth 6 or 7 ft. high. A small flat bottom boat was used to carry the drill across the river, there being consumed about half an hour to do this. As there are no roads in Colombia it would be almost impossible to work a steam drill, owing to the difficulty of moving it from place to place.

Four men were used to turn the casing, and four men did the drilling, an additional man being used for cutting trails. The entire crew was used to draw the casing and move the drill from hole to hole. The following is a record of seven days' work:

First day.—Carried outfit across river in boat and began hole No. 1. Made 14 ft. in top soil and 11 ft. in gravel by 5 p. m.

Second day.—Finished hole No. 1, 2 1-2 ft. more to bed rock, total 27 1-2 ft. Pulled casing and began hole No. 2, 100 ft. distant before noon, and sunk the hole 17 ft. deep to bed rock before 4 p. m. Pulled casing and moved to hole No. 3, drilling 9 ft. in overburden.

Third day.—Finished hole No. 3, 24 ft. deep. Pulled casing and started hole No. 4 by 2 p. m. Passed through 12 ft. of overburden and 10 ft. of sand and gravel by 5 p. m.

Fourth day.—Finished hole No. 4, which was 28 ft. deep to bed rock. Pulled casing, cut trail and moved to hole No. 5, 300 ft. northeast of hole No. 4, and started new hole by noon. After drilling 17 ft. through overburden an old buried tree was struck, but the drill went through it easily. By 5 p. m. 22 ft. were made in this hole.

Fifth day.—Finished hole No. 5, 28 ft., and after pulling casing began hole No. 6. Got down 14 ft. in overburden and 9 ft. in gravel by 5 p. m.

Sixth day.—Finished hole No. 6, going down 9 ft. more to bed rock. Moved outfit across the river and about a mile up the river, and at 2:45 started hole No. 7. Made 6 ft. in overburden and 9 ft. in gravel by 5 p. m.

Seventh day.—Finished hole No. 7, 29 ft., to bed rock, and moved 50 ft. north and sunk hole No. 8, 22 ft., to rock. Started hole No. 9, 50 ft. north, and made 6 ft. in top soil by 5 p. m.

Thus in seven days of drilling 213 1-2 ft. were drilled, an average of 30 1-2 ft. per day. It will be noticed that as the men became accustomed to the work, they improved a little each day.

With the Empire drill an auger drill spoon is used that will cut through hard soils, roots and sunken logs and easily penetrates gravel. It picks up any material and brings it as a core to the surface with a minimum amount of disturbance of the material as it actually lies in the ground. Water, as a rule, is not used to assist in drilling, so the auger will pick up the finest particles of gold. If it is desired to use water in drilling it can be done. The casing is pulled by levers with a very simple device.

With wages at $1 per day for the men the expenses were about $10 per day, allowing $1 for incidentals, the cost per ft. was about 33 cts. With standard wages the cost per lin. ft. would have been about 47 cts.

Particulars have been issued of the English war office scheme, states "The Surveyor," for establishing a special reserve of officers from the ranks of the civil engineering profession. The candidate must satisfy the general conditions as to character, fitness and education, and must be between eighteen and twenty-five. Special requirements of the corps are satisfied if he has passed the examination as associate member of the Institution of Civil Engineers. If accepted, he at once undergoes twelve months' training with the regular army before he engages in private practice. He serves as second lieutenant on probation partly with the regular unit of the Royal Engineers and partly at the School of Military Engineering. He receives an outfit allowance of £40 and pay of 10s 7d. per day. His first year's training is apportioned: Military, 80 days; fortifications, 105 days; survey, 30 days; construction, 30 days; and the rest in the actual duties of the Royal Engineers, in barracks or in the field. After the first year the officer must put in fifteen days' work per annum, at 11s 7d a day. He may rise to the rank of major, but each step must be preceded by a full month with the colors. Facilities will be offered for transfer to the regular army.

In his annual report Secretary of the Interior Garfield urges the establishment of a regular bureau of mines to have charge of the whole field of mines, mining and minerals.

Roads and Streets Section

Note: This Section is devoted to methods and costs of road and street construction. It will cover road building in all its details, the construction of pavements, sidewalks and gutters, the testing and use of paving materials and the machinery and tools used in road building and paving.

Standard Details for Highway Construction.

The Massachusetts state highway commission was established in 1893 and since that time several hundred miles of macadam road have been constructed under its supervision. The commission has a very excellent set of standards for its road construction work. The accompanying cuts show a number of standard details of the commission.

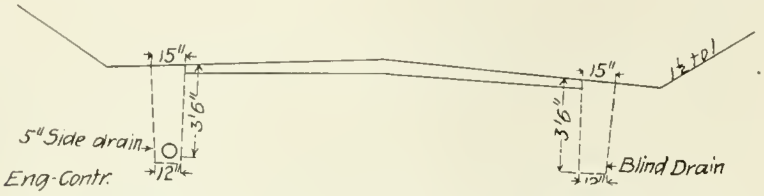


Fig. 1—Cross Section Showing Types cf Side Drains.

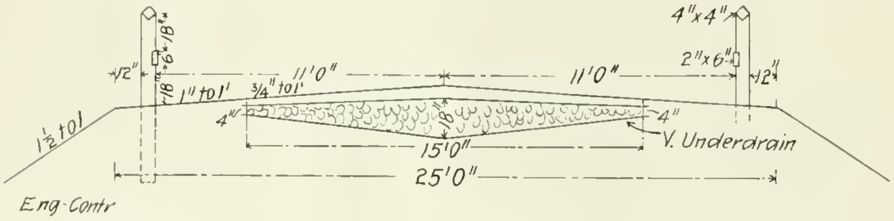


Fig. 2—Cross Section Showing V-Underdrain and Guard Rail.

Figure 1 is a standard cross section showing types of side drains. These are constructed just outside the limits of the macadam. They consist of narrow trenches, filled with broken stones or small gravel stones, with a 5 in. pipe near the bottom. The pipe is laid with open joints, true to grade and is carried to a proper outlet. In the case of a blind drain the pipe is omitted and the entire trench filled with stone, large stone, 3 in. to 8 in. in size being placed at the bottom and graded to fine at the top.

In constructing these drains the trench is excavated to a width of 15 in. at the top and 12 ins. at the bottom. When the grade of the finished road is 3 ins. or more to the 100 ft the bottom of the trench is made 3 1-2 ft. below the finished surface of the road. In the case of the pipe drain 2 ins. of gravel or broken stone of a size which will pass through a 1 1-4 in. mesh and not through a 1 2 in. mesh is placed on the bottom of the trench. On this is laid the 5 in. salt glazed vitrified clay pipe with bell and spigot ends, the bell ends being toward the rising grade. No pipe is laid on a grade of less than 3 ins. in 100 ft. Gravel or broken stone of the sizes mentioned previously are filled about the pipe and over it to a depth of 1 ft. This is carefully tamped about and rammed over the pipe. The remainder of the trench is filled with stone which will pass though a 3 in. mesh and not through a 1 in. mesh, and is thoroughly tamped.

Figure 2 is a standard cross section showing the V-underdrain and guard rail In constructing the V-underdrain a trench of a width identical with the width of the macadam is excavated for a depth of from 12 to 18 ins. in the center and to a depth of 4 to 8 ins. in the side, and shaped on the bottom like a flattened letter V. This trench is filled with field or any sort of stones varying in size from the smallest obtainable to such as are 8 or 10 ins. in diameter. The large stones are placed at the bottom and the small stone and gravel at top. No especial care need be used in placing the stones, except that they be placed so as to permit of consolidation by a roller. The bottom of the trench should be tolerably true to grade, and cut off lateral trenches filled with stones are necessary to carry the water to proper outlets. The average contract price for stone filling for V-drains in place in Massachusetts in 1906 was $0.827 per cu. yd. The guard rail fencing (see Fig. 2 and Fig. 3) is placed on edges of embankments and at such other places as the engineer may deem necessary. The posts are of well seasoned, straight, sound chestnut or cedar, not less than 6 ins. in diameter. They are spaced 8 ft. apart on centers, the bottom of each post being set 3 ft. into the ground and 3 1-2 ft. above the ground. The backs of the guard rail posts are set 1 ft. from the edge of the embankment for all widths of roadway. All bark is removed from the post before setting and all knots hewed down to face and the exposed surfaces shaved. The top rails are 4 ins. square and the side rails of 2x6 in. well seasoned wood, spruce preferably, planed, free from loose or unsound knots. Both top and side rail are notched into and securely fastened to the posts as shown in Figs. 2 and 3, and are long enough to extend over three posts and break joints. All parts of exposed surface of the fence are painted with one coat of white lead and linseed oil. At culverts square iron posts, 1 1-4 ins. square, are used. The posts are set into the coping stone at least 4 ins. and leaded. The side rails are bolted to the iron posts with two bolts set in holes drilled through each post. The average contract price in 1906 for guard rail in place was $0.277 per lin. ft.

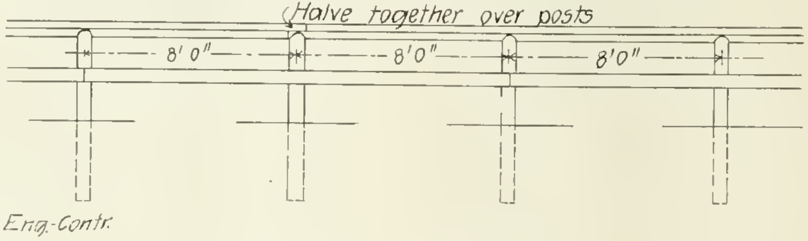


Fig. 3—Wooden Guard Rail.

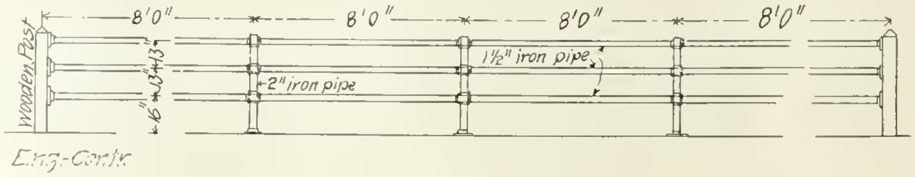


Fig. 4—Iron Pipe Fence.

Figure 4 shows a section of iron pipe fence and Figs. 5 and 6 show some of the details. The cast iron flange for the base of the iron post is 2 in. x 6 in. in size, and the railing flange for wooden post is 1 1-2 in. in size.

Figures 7, 8 and 9 show types of catch basins, with 2x2 ft. grates. Fig. 7 shows a catch basin constructed of Portland cement concrete, Fig 8, a stone masonry catch basin and Fig. 9 a brick catch basin In the case of the brick catch basin with a good foundation the lower course of brick work is omitted. Hard burned bricks are used for the brick catch basin and the bricks are well soaked in water before being laid. The joints are thoroughly flushed full of mortar, consisting of 1 part natural cement of the best quality and 2 parts of coarse, clean, sharp sand. No joint on the face is made greater than 1-4 in. and after the bricks are laid the joints are neatly pointed on the inside. As the walls are laid up they are well plastered with mortar on the outside. The average contract price in 1906 for catch basins in place (including catch basin frames and grates) was $35.74 each.

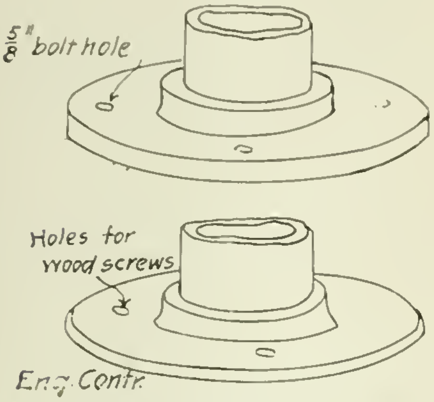


Fig. 5—Flange for Base of Iron Post and 1½-in. Railing Flange.

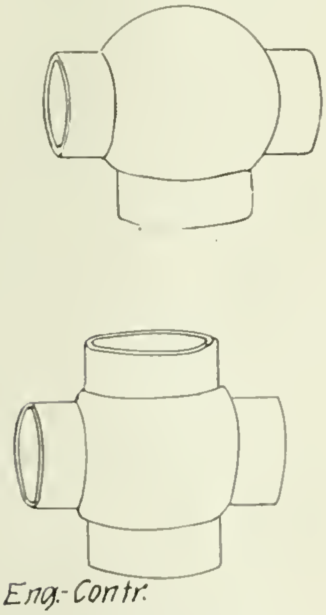


Fig. 6—Tee and Cross for Iron Pipe Fence.

Figure 10 shows a stone drop inlet These are also constructed of concrete. When built of concrete the walls are made 12 ins. thick and the bottom 8 ins. thick. With a good foundation the bottom is omitted in both cases.

Removing Snow From Streets With a Road Grader, and Some Costs.

The most economical removal of snow that has ever been made in New York City, it is stated, was performed in one of the districts, into which the city is divided for that purpose, during the storm that visited that city the week of Dec 20, 1908. The work was done with the aid of the 20th Century Grader, manufactured by the Baker Manufacturing Co., of Chicago, Ill. The contractors for one of the districts of the city had purchased 12 of these machines to be used for snow removal and had them in readiness for the first storm.

These contractors, the Philip T Brown Co., are the first contractors in New York to adopt a more up-to-date method of snow removal, than using shovels and scrapers to pile the snow, to be hauled away afterwards. The 20th Century Grader throws the snow from the middle of the street to a long pile at the gutter, from which it can be loaded into wagons and hauled away. It is stated that these graders or plows paid for themselves in the first three days, as each one did the work that it would have been necessary to employ 30 to 40 men to do. The snow from this district was removed promptly, while in some other parts of the city snow remained so long in the streets that it turned into

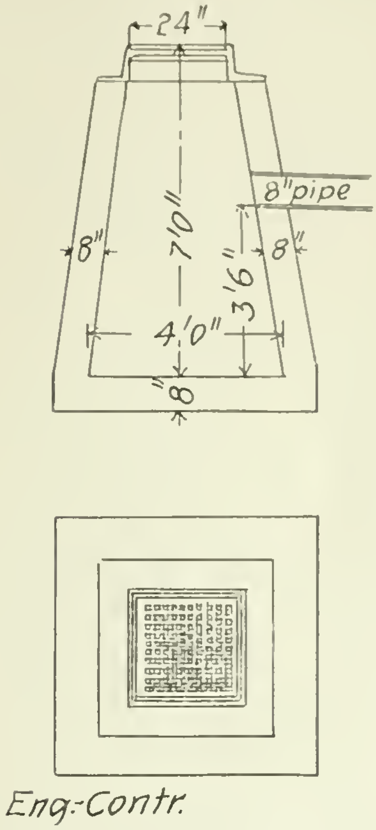


Fig. 7—Concrete Catch Basin.

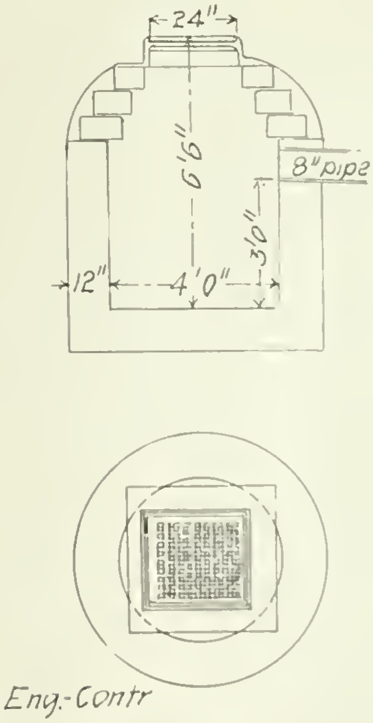


Fig. 8—Stone Catch Basin.

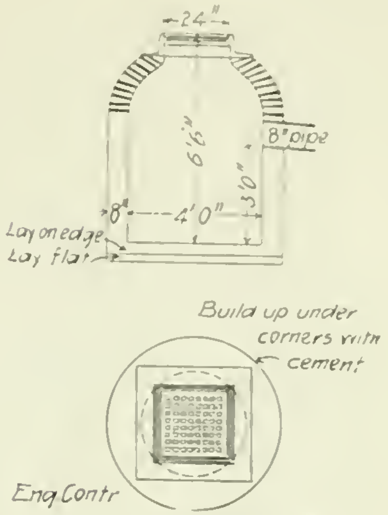


Fig. 9—Brick Catch Basin.

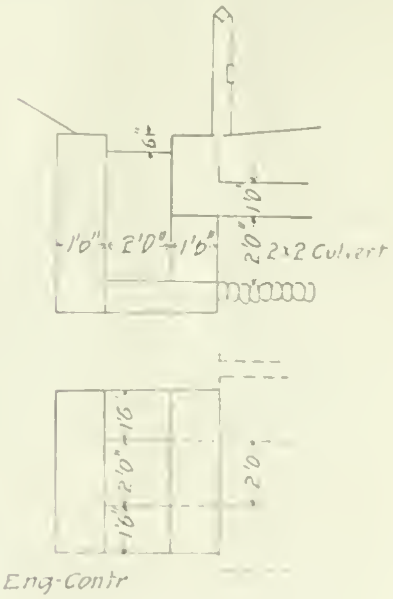


Fig. 10—Stone Drop Inlet.

slush, much to the discomfort of those using the streets. We are informed that these 12 plows moved as much snow as was done by the rest of the forces in the city, in the same time.

The timing of three of these plows at work, just after the snow stopped falling, showed that they piled up the snow on 54,500 sq. yds. of asphalt paving, the three plows working one behind another, beginning at the center of the street and working toward the gutters, in 2 hours and 15 minutes. This work was done on three different streets. The snow was 3 ins. in depth; for a less amount of snow the contractors are not called out. At the prices paid for snow removal there is seldom any profit in this depth of snow, but the contractors state that with the aid of the plows some profit was cleared on this first storm.

With wages at 60 cts. an hour for two horses and a driver, the cost of plowing the snow into the long piles at the gutter for the 54,500 sq. yds. was $4.05, making a cost of 7 cts. for each 1,000 sq. yds. and a cost of about 1 ct. for each 10 cu. yds. of snow removed. It is needless to say that this is a very low cost as compared to doing the work with shovels. In doing this work the teams traveled at the rate of 2.3 miles per hour, or 23 miles during a 10-hour day.

The blade on the plow used for snow is 7 ft. long, and cleans a width of from 5½ ft. to 6 ft., according to the angle at which the blade is set, for each trip of the plow. A greater depth of snow could have been handled just as economically. The plows can also be used to clean sidewalks. On account of the success of these plows the contractors have ordered 12 additional ones.

At the annual meeting of the Washington Society of Engineers at Washington, D. C., on Dec. 15, the following officers for the ensuing year were elected: President, D. S. Carll, vice-president and general manager Capital Traction Co.; vice-president, W. A. McFarland, superintendent of water department, D. C.; secretary, John C. Hoyt, engineer United States geological survey; treasurer, J. B. Gordon, civil engineer. Directors: G. R. Putnam, W. C. Allen, W. P. Upton, A. E. Phillips, C. S. Kimball and C. B. Hunt.

At a meeting of the Association for the Advancement of Science, at Baltimore, Md., on Dec. 31, Dr. L. O. Howard, chief of the Bureau of Entomology, United States Department of Agriculture, in an address estimated that flies and mosquitoes caused an annual economic loss in the United States of $200,000,000.

At Le Mans, France, on Dec. 31, Wilbur Wright, the American aeroplanist, made a flight covering a distance of 73 miles. He remained in the air for two hours and nine minutes. By this flight Mr. Wright won the Michelin cup, valued at $5,000

Water-works and Sewer Section

Note: This section is devoted to methods and costs of constructing sewers and water-works. It will cover the construction work for all details of water supply and sewerage, including sewage purification and water filtration.

Water-Works Valuation and Fair Rates in the Light of the Maine Supreme Court Decisions in the Waterville and Brunswick Cases.

(Continued from p. 440, Dec. 23 issue.)

GOING CONCERN VALUE.

The Maine Court has ruled that the "going concern" or "established business" is an element of structure value. It may be defined as the cost of establishing, up to the level of the net income of the old plant at the date of taking, the business of a similar new plant (but not of a more perfect system which the city might build), which is supposed to begin operation upon the date of the taking, the old plant going out of business at the same moment. Or, to put the same thing in another way, it is the measure of the greater value (at the date of taking) of an old, established plant, over a similar new plant, completed and ready for operation upon the date ot taking. Or, to put the same thing in still another way, it is the measure of the cost of developing the business of a new plant to a point coincident with the net income, upon the date of taking, of the old plant.

Hence the "going concern" or "established business" element of value—subject to the fairness of the rates and the character of the service—depends directly upon the net income or earning capacity of the works at the date of taking, and there does not appear to be justification for including in this value, as some experts in water-works valuation have done, consideration of the increment in net annual income in the period of years after the date of taking, during which the business is being established. The latter (increment) clearly pertains to franchise an not to going concern value. As previously stated, the concern going value is only one element of value, included in the total value found by capitalization or consideration of the net income under reasonable rates. To add the going concern value to the total value would involve double payment for the same thing, but in the case of the plant the franchise of which has expired, the going concern value must usually be calculated and added to the reproduction cost less depreciation thereon to date, in order to determine the value of the plant.

In passing it may be of interest to suggest certain underlying principles bearing upon the going concern element of value. In the course of their development and life history most water-works plants pass through the following phases:

1.—That of the plant which has not been operated for a sufficiently long period of years to develop its normal revenue or rate of growth, or, in other words, that has not passed through the formative period.

2.—That of the plant which has passed through the formative period, but which has not yet made good, through its increasing revenues, the losses sustained in the early years of the formative period.

3.—That of the plant in which the going concern has been established, and the losses during the formative period have been made good.

1.—If the works be taken by the city while they are still in the formative period, or period of business development, it is clear that the net revenue does not furnish an equitable means of determining the value of the property, since there is no net revenue, and this fact should be given due weight. If the owner of the works should attempt to sell his plant during this period, the purchaser or investor would probably give small recognition to this fact; the sale would be in effect in the nature of a forced sale, and hence the owner would probably not derive a reasonable return for his property, even from a willing purchaser. On the other hand, if the valuation of the works is based upon the taking by the municipality under right of eminent domain and hence upon their value to the owners, subject to limitation of reasonable rates and reasonably good and efficient service, as it must be under the Maine decisions, this fact must be given due consideration.

2.—If the works are bought immediately at the end of the formative period, but while the owner is still carrying the accumulated losses of the early years, this fact should be given due weight in arriving at a valuation based upon the earning capacity of the plant when taken by the city. The same idea might be stated differently by saying that, at such a time, the seller would not be a willing seller but a forced seller. It cannot be doubted that if the works should be purchased by an investor or a willing buyer at that time, he would make no allowance to the owner for any losses incurred by him in the early years of operation, except in so far as prospective earnings might warrant some small consideration, for the value would be derived and the market price be paid as a result of the going concern, the established business, and the earning capacity, and not as a result or measure of the works having passed the early hazard period. In the case of a plant taken under the right of eminent domain or legislative authority, however, the valuation must be made on a basis of the value of the works to the owner subject to the limitations of reasonable rates and service, in which case the fact cited above should be given due weight, and, in case of fair-rates suit, due consideration should be gvien, in a study of the rates, to the fact that the owner had not been reimbursed up to that time for the early losses, and this condition would result in the postponement of the day when the community might justly expect a reduction in the rates for water service.

3.—Finally, in the case in which it is assumed that the company has been reimbursed, through the agency of the rates, for the losses during the early years of development, the full value of the going concern has been established, and the owner has received adequate return upon his property up to date of taking; and it may be added that a new situation has arisen, under which the rates, previously equitable, are beginning to be unjust to the community, unless increased extensions and improvements to the property or service make a drain upon the revenue commensurate with the surplus earnings which had previously been applied to the liquidation of the early hazard debt, or the losses incurred in establishing the business.

If it is a fact that after a reasonable period of growth, which period could not well exceed ten years, and, in many cases, a less period, the normal income of the company has not been developed, and it is still being operated at a loss, no other conclusion can be drawn than that the owner of the property has voluntarily taken upon his shoulders a losing contract with the community, the penalty of which he must, under the terms of that contract, pay, without increase in rates and with disadvantage to himself, in case he should attempt to sell the property. As owner he was not obliged to enter into contract with the community to supply water to it, or to accept the franchise which it offered, but having done so, under the law of contracts, he must suffer the consequences to the limit of his financial ability. These losses, under the circumstances cited, would be the measure of the price which the owner would have to pay for the privilege of the continued enjoyment of his franchise.

In the writer's experience, the going concern value has usually been found to be between the net and the gross income of the plant for a period of one year (at the date of taking). It may be largely affected, however, by the period required for the development of the business.

FRANCHISE VALUE

The franchise rights usually cover fundamentally the right to take and develop sources of water supply, condemn property necessary for the use of the waterworks, use the streets, highways and public places, supply water to consumers for domestic and commercial purposes, and to collect tolls or water rates therefor

Its value cannot generally be determined directly. If desired, it must be obtained by eliminating from the total value of the property the remaining elements of value, if this is possible.

THE MEASURE OF FAIR RATES.

Much has been said by counsel in different cases upon the unreasonableness of the rates, with but little effect, however, as no measure has been given of the extent or degree of the unreasonableness or of its effect upon the consumers individually or collectively

Fair rates cannot be determined by comparison of water rates in neighboring or similar communities, since identical conditions probably never exist, and weight can not be given readily or intelligently to the different causes which might affect them. The Court has always recognized this fact and wisely excluded direct comparison of rates. Nevertheless, it is probably true that rates in similar communities do have weight in limiting the magnitude of the rates.

It has remained for Judge Savage to furnish the proper gauge or yard-stick with which to test the fairness of the rates—the worth of the service to the consumer, as well as the fair return to the water company.*

Here is a frank recognition of the obligations of the public servant on the one hand, and of its rights on the other. The water-works corporation is not engaged in a private business for profit, limited only by competition and the laws of supply and demand, but in the performance of a public duty, subject to the requirements of efficient service and fair rates and privileged to make profit under non-competitive conditions. The property of this quasi municipal corporation, therefore, cannot have, or be valued upon the basis of, "market value." In appraisal, its value, under the Maire opinions, must be the "value to the owner," subject, however, to the limitations of the efficiency and the worth of the service to the consumer, or, in other words, of fair rates for water service of the character furnished

Obviously, it cannot be expected that the cost of this service will not exceed the cost to the public of supplying itself; for it is reasonable to suppose that, inasmuch as the public elected for one reason or another to grant the franchise for water works to a corporation, it was willing to pay somewhat higher rates than those at which it might have supplied itself. This excess is a matter of judgment in the light of all the existing facts, but the Court calls attention to the need for caution in applying this rule, since the company, in accepting the franchise, voluntarily chose to take whatever hazard there was in the business; and further holds that whatever the consequences or loss to the owner, the rates must not, in any event, exceed the worth of the service to the consumer

Heath's Method of Measuring Fair Rates and Value.—As counsel aptly put it, one cannot value without rating, and once one has determined the fair rates for a given plant, one has valued it

The method of rating and valuation outlined herein was first developed and used, so far as the writer knows, by Hon Herbert M. Heath, of Augusta, Maine, in the suit of the Kittery (Maine) Water District *vs.* the Agamenticus Water Company, in November, 1907, and later in two other water-works valuation suits—Livermore Falls Water District *vs.* Livermore Falls Water Company, heard in November, 1907, and the Portland (Maine) Water District *vs.* the Portland Water Company, the Standish Water and Construction Company, the Gorham Water Company and the Foreside Water Company, heard in February to May, 1908 Mr Heath had previously had considerable experience in water-works litigation and valuation, and had given much study in his wide practice, as a corporation lawyer in New England, to the important economic questions involved in the relations of the quasi-municipal or public service corporations to the public; but it was not until the Brunswick decision that this principle of the worth of the service to the consumer was laid down by the Court, and first put to practical application by Mr. Heath. As the writer had the pleasure of assisting Mr. Heath in working up his theory (or method of applying this principle) and the tabulations for his argument in all three of the above mentioned cases (Kittery, Livermore Falls, and Portland), he may be permitted, perhaps, to outline it.

The theory was probably the outcome of a critical study, by Mr Heath, of the rating question, of the rules of valuation and fair rates laid down by Judge Savage in the Waterville and the Brunswick opinions, of the previous valuation litigation in Maine and elsewhere, of the English methods which governed the valuation of the London water companies, and of his interest in the broad economic principles and questions of public policy involved in the relations of quasi municipal corporations to the public

Value, Mr Heath holds, must be based upon cost—be the latter reproduction cost, based upon prices prevailing on or about the date of taking; or reproduction cost based upon fair average prices for a considerable period of years; or original cost; or something between these three—upon cost plus a profit which shall be limited, upon the one hand, by what may be needed to induce investment in and active competition for the privilege of operating public service corporations, and, upon the other, by the cost at which the public might serve itself equally efficiently plus the profit which the public might be willing to allow to a corporation for doing the work and thus relieving it of the necessity and, perhaps, risk of serving itself.

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*See 99 Maine, 371 Pars 6, 7, 14 and 13

Starting with this fundamental idea, that the public service corporation is entitled not only to the reasonable cost of furnishing the service, but also to a reasonable profit thereon (assuming always that the works can earn the necessary income to admit of this), we come logically to a consideration of the principal elements or factors to be covered by the rates, and hence to what might be termed the maximum lawful income for the given plant under existing circumstances—for any increase in earnings beyond this point should, by the law of diminishing returns, revert or inure, sooner or later, to the public, in one form or another. To say that, in a consideration of the lawful annual income to be derived from the rates, no allowance, beyond operating expenses, depreciation, and a reasonable return upon invested capital, should be made to the builder or owner of the works, would be contrary to public policy and expediency. Under such conditions capital could not be induced to embark in such ventures, and progress might be seriously handicapped in many communities.

Elements to be Covered by Lawful Rates.—Subject to the limitation of the Court ruling, that the rates shall be reasonable to the individual as well as to the community as a whole, and to the practical business-possibilities involved in the case or the willingness of the people to become water takers at the established rates, the corporation is entitled to fix its rates so as to earn:

First.—Full operating expenses, including therein all necessary repairs to keep the plant in good condition.

Second.—A depreciation or renewal fund, which shall always keep intact the capital invested, by replacement through this fund of the worn out or described parts of the plant.

Third.—Such a rate of interest upon the invested capital as will correspond to the degree of hazard involved in the investment.

Fourth.—Interest upon the reasonable profit increment (discussed in the following pages) which is assumed as compensation for undertaking this public service.

Fifth.—A sinking fund, if approved by public. The question as to whether a sinking fund should or should not also be earned and allowed is perhaps a "local-option" question, inasmuch as it merely affects the distribution of the burden of construction, and not its amount.

If a sinking fund be added, the item of interest upon invested capital included above would be omitted, of course, after the amortization of the debt of construction by the sinking fund. If the annual contribution to the sinking fund be large, the construction debt will be quickly paid, but the present burden will be heavy upon the consumer; if it is small, the period will be lengthened and the burden decreased. Views differ upon this question which is after all one of sound public policy. The occasional needs or burdens growing out of war, fire, earthquate, flood, or other disaster, which have befallen cities from time to time, dictate or at least indicate the wisdom of letting each generation bear its own burdens and of making regular contribution to a sinking fund, which will wipe out the construction debt within a reasonable period of time, such as 20 to 40 years.

Referring now in greater detail to these elemental considerations in determining rates, the "operating expenses" need no comment, and "depreciation" has already been discussed; the "rate of interest," the "base upon which it is to be figured," and the "reasonable profit" are not so easy of determination.

The Rate of Interest.—This rate should not be that at which the city or town could borrow money, even upon its water-works securities, as the community's credit rather than the actual hazard would be reflected in this rate; neither should the rate at which the company has borrowed money be controlling, though it may be confirmatory evidence. The customary rate of interest prevailing upon securities or loans of equal security or hazard should govern. In New England, rates of 5 to 6% may be considered, perhaps, as typical of average conditions in recent years.

Under the method of valuation discussed herein, the rate of interest actually adopted and used makes no difference in the final valuation of a plant which is earning its maximum lawful return. It pertains only to the rating, to the determination of the maximum lawful income from the given investment under existing conditions. As far as the value goes, it makes no difference whether the rate be assumed to be 5 or 10%, for having once determined the lawful, annual income (based upon this given rate), the value may be obtained by capitalizing this income at the assumed rate of interest, or, what is exactly the same thing, having determined the base on which interest and profit are to be calculated (in the building up of the lawful income), the value is obtained by increasing this base by the profit increment, or ratio, to be allowed for assuming this public duty or performing this public service. This subject is further discussed under a latre paragraph upon "Reasonable Profit."

The Base on Which the Interest is to Be Calculated.—This factor requires the most careful thought. Should interest be computed, first, upon the reproduction cost at the time under consideration; or, second, upon a fair average reproduction cost during a period of years long enough to give normal or mean business conditions; or third, upon actual cost of the works? The courts have prescribed the first, as one of the fundamental considerations of value, but they have also attached great value to the last. The second method has always seemed to the writer, on the whole, the most equitable of the three.

In figuring the cost to the public of supplying its own service, this cost may be based upon the reproduction cost of the plant, upon the theory that the rating is made as of the date of taking, and current prices, therefore, should control, or upon the original cost, on the theory that the company is entitled to a consideration of its actual investment. Each method has its objections, the former, in that in a period of exceedingly high, if not actually inflated, prices for materials and labor, such as that through which we have passed recently, the reproduction cost would be abnormally high and as injurious and unfair to the public as would be the conditions to the company under abnormally low prices; the latter, in that the town is no more entitled to the benefit of the particular advantages accruing to the company for unusual good fortune, or economy of or shrewdness in construction, than it is to be held responsible for any negligence, bad judgment, or lack of prudence, foresight or economy on the part of the company. There would seem to be some justice, therefore, in basing the cost-to-the-public-of-furnishing-the-service (as a gauge of fair rates to the company) rather upon what might be termed the fair average prices for a period of years, than upon the actual reproduction or original costs, though the Maine Court has said that reproduction cost should be figured on actual prices and that the owner is entitled to any appreciation, or must suffer the loss due to any depreciation, growing out of change in prices since the original construction.

In the case of a limited and expiring franchise, too, the reproduction cost, as of that date, decreased by the depreciation to date and increased by the going concern value, would seem to furnish the proper basis for valuation under existing laws, though, in equity, it would appear fairer to compute its reproduction cost on average prices prevailing over a past period of years, rather than upon actual prices at the time under question.

The Reasonable Profit Increment or Allowance.—The reasonable ratio or excess of profit over cost to be allowed to the public service or quasi-municipal corporation is largely a question of good sound judgment based on an intimate knowledge of all the facts and the local circumstances bearing upon the case in question. Generally speaking, this ultimate ratio, corresponding to the development of the maximum lawful income for any given investment, may lie between 25 and 50%, but even these limits may be exceeded.

With good, energetic and thrifty management, the maximum development and profit increment will be reached early in the history of the plant and may be maintained throughout its life; with bad management, its development will be delayed or may never be reached, and even the original investment or capital may be impaired or lost.

Tht profit ratio, as indeed the interest rate, is thus dependent on the character and stage of development of the plant; on the magnitude of the project; the character of the community, its size, rate and permanence of growth, wealth, comparative safety, stability, prosperity, liberality, nationality; on the attitude of the community and of the courts; and on the character of franchise; physical environment as affecting possible competition; the character and efficiency of the physical plant; the physical risks; the provision for future needs, etc.

In this connection attention should be called to three considerations, sometimes lost sight of, which should be borne in mind in reviewing past operations of any corporation with reference to present valuation or rating:

First.—The difference in the water-works standards of today, as compared with those of the past.

Second.—The change in attitude of the public toward quasi-municipal corporations, the progressively closer public supervision of their operations, and the greater limitations put upon them.

Third.—The extent to which the past operations and earnings of the company, at rates which have not been challenged for a long period of years, may be presumptive evidence of their supposed fairness from the public point of view regardless of actual cost to the company of furnishing the service, and even though they may show to the company an unreasonably large profit upon the actual capital invested.

Fourth.—The effect of past determination of value or of fair rates by legal or judicial procedure after litigation of these questions.

The third consideration is one of the most difficult to handle, for, on one hand, innocent investors who have purchased water company securities upon a basis of their earning capacity or market value, under rates long in force and never called into question, are ranged against the public with its right to demand efficient service at rates that are not exorbitant to the water consumers, either individually or collectively, and that shall show to the company and its investors no more than a reasonable profit upon its property.

If the property or rates have been subject to controversy and legal adjudication prior to the valuation, the results reached at that time would seem to furnish a suitable starting point for subsequent valuation, and, perhaps, prevent the possible oversight of the elements referred to.

Disposition of Excessive Rates.—If, judged by the worth of the service to the consumer, the rates are excessive, the excess should apply to reduction in rates, betterment of service, if the latter be needed, or to reduction in debt; and any increase in net annual income (over and above the demands of increased operating, maintenance, or fixed charges growing out of additional investment) should apply to the same end—reduction of rates; or, as Mr. Heath, Counsel for the Livermore Falls Water District, aptly put it, in his final argument:

"* * * Any additional net income derivable here would be excessive; and we would approach that stage in rating when, as they call it in the books, under the law of increasing returns, the new additional net income should inure to the benefit of the public served. * * *" and Mr. Heath went on further to draw a parallel with the history of the railroads of the United States which, with increasing tonnage, have been able to reduce their rates enormously.

"This is but the natural operation of the economic law in public channels, a recognition of it by men who knew and understood that they were public servants: and that as the business increased the public got the benefit of it.

"* * * We have shown that the day has come in the history of this plant when the future increment in income belongs to the people by way of reduction of rates, a just principle, Mr. Chairman, because a certain amount having been invested by somebody, having built a good plant, having covered the area, then there should be an hour some time in the history of this and all water companies when they reach the maximum net income that is lawfully derivable, holdable and keepable from that plant; and when you go beyond that, the hour of the people has come to receive proper reductions in their rates. Now assuming that I am right in these propositions, let us view the matter from the standpoint of the element of fairness to the company. The Court has said * * * in this Brunswick decision, * * * that the amount of money actually and wisely expended is a primary consideration in this matter of a fair return; and it ought to be, because the money invested ought to be protected by the courts and legislature, so far as can be done with justice to the public; and if it be that they can get a fair return upon money originally expended, at the same time doing it without oppressing the people, and not exceeding the worth of the service to the community, they ought to have it—otherwise we would have no water-works."

The owner of the water-works benefits not only by the allowance to him of a return in excess of the cost to the community of furnishing a like service, but also by the greater security of his investment growing out of the just recognition of these principles.

Extracts from Argument of Hon. Herbert M. Heath, Counsel for Water District in Portland, Maine, Case, upon Method of Valuation, Reasonable Profit Ratio, and Rate of Interest to Be Allowed upon Capital Used.

[This part of the original paper covered seven pages and is omitted from our abstract.—EDITORS.]

Application of Foregoing Principles in the Livermore Falls Water-Works Valuation.

[This part occupied 6 pages and is omitted.—EDITORS.]

(To be concluded.)

A plan has been submitted to the New York State Public Service Commission by Mr. Duncan D. McBean for a freight subway system for New York city, to cost about $130,000,000. The plans propose the construction of tunnels and subways to bring the passenger trains of the Central Railroad of New Jersey, Baltimore & Ohio R. R., Lehigh Valley R. R., Philadelphia & Reading R. R., Erie R. R., Delaware, Lackawanna & Western R. R., New York, New Haven & Hartford R. R. and Long Island Railroad (Bushwick branch) into a union passenger station in Manhattan located at the site bounded by Park Row, Oliver street, Cherry and Pearl streets. The plan also proposes to enable the above railroads and also the Pennsylvania, Lake Shore, New York Central and the Harlem R. R. to deliver their freight cars in Manhattan and the Bronx through combined railroad and roadway subways constructed in the following streets: West street, from Liberty street to 22d St., thence in 11th Ave. to 42d St.; in South St., from Whitehall St. to Gouverneur Slip; in West Broadway, from Vesey St. to Fifth Ave., in Fifth Ave., north to 23d St. and Broadway, in Broadway, from 23d St. north to 34th St. and Sixth Ave., in Sixth Ave., from 34th St. north to 59th St.; in 79th St., from First Ave. to Lexington Ave., in 86th St., from Eighth Ave. to Broadway, in Seventh Ave., from 110th St. to 145th St.; in Willis Ave. (Bronx), from 134th St. to 148th St.

The incoming governors of five New England states, Maine, New Hampshire, Rhode Island, Massachusetts and Connecticut, are to recommend to the respective legislatures that uniform laws be passed in regard to forestry, fisheries and automobiles.

Bridges, Buildings and Foundations

Note: This section is devoted to methods and costs of constructing steel and masonry bridges and buildings and of foundation work of all kinds. It will give special attention to erection plant and tools, falseworks and centers and cost data of all kinds.

Design of Centering for 233-Foot Concrete Arch Walnut Lane Bridge, Philadelphia, Pa., With Some Comparisons of Cost.

For very long concrete arches the problem of construction outranks the problem of structural design in difficulty, and is at least equally as important. The chief problem in construction is the design and building of the centering which must support the arch, not only safely but rigidly, during construction. Very few arch centers of over 200 ft. span have been designed because engineers have built very few arches of such span. Such large centers might be considered to be of minor interest, therefore, were it not for one thing, which is that reinforced concrete is offering opportunities to engineers for long span arch bridges, which the cost and structural limitations of cut stone made comparatively rare. There is now nearly completed at Philadelphia, Pa., a concrete arch of 233 ft. span; foundation work is in progress at Cleveland, Ohio, for a concrete arch bridge of 280 ft. span, and all engineers have in mind the proposed Hudson Memorial bridge at New York, with its mammoth arch span of 703 ft. In Europe a concrete arch of 259¼ ft. span has just been completed in Switzerland. The design of long span arch centers, therefore, assumes a position of practical interest to engineers which formerly it perhaps did not have, and data bearing on the problem are of value.

The design of the center for the 233-ft. arch, Walnut Lane bridge, at Philadelphia, is described by Mr. George M. Heller in the "Proceedings of the Engineers' Club of Philadelphia," for July, 1908. Comparisons were drawn by Mr. Heller between this center and those of two European arch bridges of similarly large span. We have redrawn the illustrations and abstracted the main portion of this discussion for presentation here.

Dimensions of Arch.—The main arch of the Walnut Lane bridge consists of two arch ribs, each 18 ft. wide at the crown and 21 ft. 6 ins. wide at the skewback; these ribs are spaced 34 ft. c. to c., and are 5 ft. 6 ins. deep at the crown and 9 ft. 6 ins. deep at the skewback; the span is 233 ft. in the clear, and the height of the soffit at the crown above the springing line is 70 ft. 3 ins.

The two main ribs carry spandrel piers and a series of spandrel arches upon which the spandrel walls are built up to the height to receive the floor, which consists of steel beams with concrete arches between, and it is upon this floor that the roadway and sidewalk paving is laid, the roadway being 40 ft. wide and the two sidewalks each 8 ft. wide. The height of the soffit of the arch above the surface of the creek is about 136 ft., while the roadway of the bridge is about 14 ft. higher, making about 150 ft.

Design of Centering.—The features therefore presented in the problem of designing suitable centering for the main arch span were, to support during construction an arch rib, whose weight per horizontal foot, exclusive of spandrels, varied from 20 tons at the skewback to 8 tons at the crown, or a total here of 3,100 tons, making an average weight of arch rib of 14 tons per horizontal foot. Besides carrying this load it was, to resist wind pressure covering an area of 232 ft. long by 136 ft high; to guard against possible freshets; to provide for a transverse movement of 34 ft., together with means of adjustment and release of supports, and to reduce the deflection of the arch during construction to a minimum.

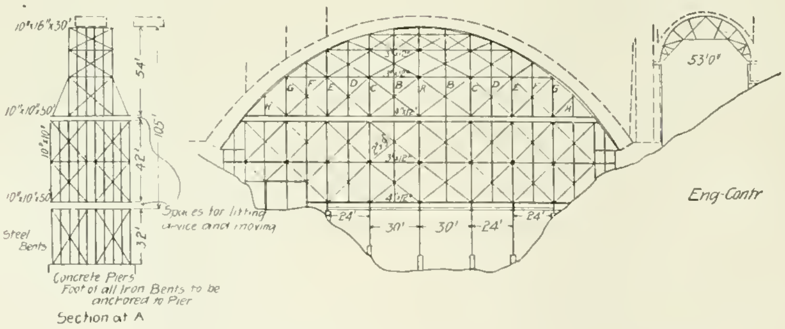

Fig. 1—Diagram Elevation and Transverse Section of Centering for Walnut Lane Bridge.

It was thought unwise to use any truss system to carry the weight of the arch during construction, for this would naturally involve deflection within the truss itself, while with a number of vertical supports each carried down to firm rock, these supports would distribute the load over a great number of points and so avoid deflection and consequently preserve most accurately the proper profile of the arch, so that when finished, the line of profile would not be marred by any irregularities in its curve.

These considerations led to the adoption of the present design, Fig. 1, in which each supporting point was made sufficient for its own part and independent of all others and capable of individual adjustment, thereby insuring the accurate profile of the arch at each point of support.

It is also necessary, while considering the nature of the design, to remark the fact of the arch itself being composed of two independent and separate ribs. This feature allowed the construction of each rib by itself and so presented an opportunity of reducing the cost of the centering by permitting one arch rib to be constructed first on centering necessary for one rib, and then, when the arch is completed, to move the same centering transversely so as to serve for the construction of the adjacent arch rib. This feature of construction was embodied in the design, and it was found not only to be feasible, but also simple and easy of action, even though the mass of timbering was so great and covered so large an area. It was also thought proper to use steel in the construction of the bottom of the centering for, as a material, it afforded better facilities for making joints capable of withstanding possible vibration in moving, and it formed a firm foundation, all parts of which acted together as a unit and allowed the whole mass to be moved true to line and without distortion or accident to its new position.

Beginning with the base of the centering, the steel trestle supports, Fig. 2, were spaced 24 ft. and 30 ft. apart and were carried on concrete piers founded upon and doweled into the solid rock. These piers were carried up to a uniform height above all danger of freshet, and they formed the basic foundation upon which the whole mass of steel and timber was designed to move. Each steel trestle was securely anchored into its pier by 1½ in. steel rods, and these rods served to guard against freshets and wind and were released when the centering was moved.

The movement of the centering was accomplished by placing on each pier a series of ten steel rollers, each 6 ins. in diameter, rolling on steel plates built into the tops of the piers; each roller was capable of bearing in safety 10 tons, making 100 tons, which was the total maximum weight at the center pier to be moved. The steel bents rested upon these rollers, and upon completion of the erection of one rib of the arch they were all moved in unison by placing jacks between the bottom end of each steel bent and a studded anchor chain which formed a cradle or saddle against which the jack worked, the ends of the chain being attached to timbers previously built into the piers for that purpose; this method of translation proved to be quite effective, and the whole distance of 34 ft. was covered in the space of three days.

The total weight moved can be fairly stated to be about 1,000 tons. This amount is found by taking the total weight of bolts, steel trestle and timber trestle, and allowing in the case of timber 5 lbs. per ft. B. M., the timber being probably very heavy from the absorption of water from the structure. This great weight, covering a length of say, 230 ft. and a width of 50 ft., was moved by jacks having a sum total capacity of 345 tons acting at 15 points.

Upon the steel trestle and its floor of 10 lines of 24-in. steel beams the timber trestle is supported, the bents being 12 ft. and 15 ft. apart. This timber trestle is made in two portions, the lower portion, called the staging, Fig. 3, being of uniform height, with its posts, caps, and sills of 10x10 in. timber, and the upper portion, called the upper trestle, Fig. 1, of varying height to suit the soffit of the arch with its posts and sills of 10x10 in. timber and caps of 10x16 in. timber. These caps carry the 6x16 in. and 6x18-in. timber joists spaced 12 ins. on centers, dressed to the curve of the arch. Upon these joists the 1½-in. tongued and grooved lagging is laid, which completes the construction of the centering. All timber was of yellow pine and thoroughly braced and bolted throughout with 2x9-in. braces and ¾-in bolts.

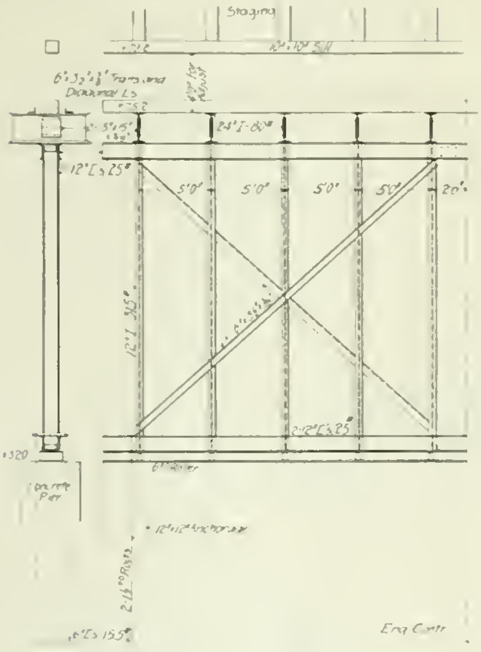

Fig. 2—Details of "Steel Trestle" Portion of Centering.

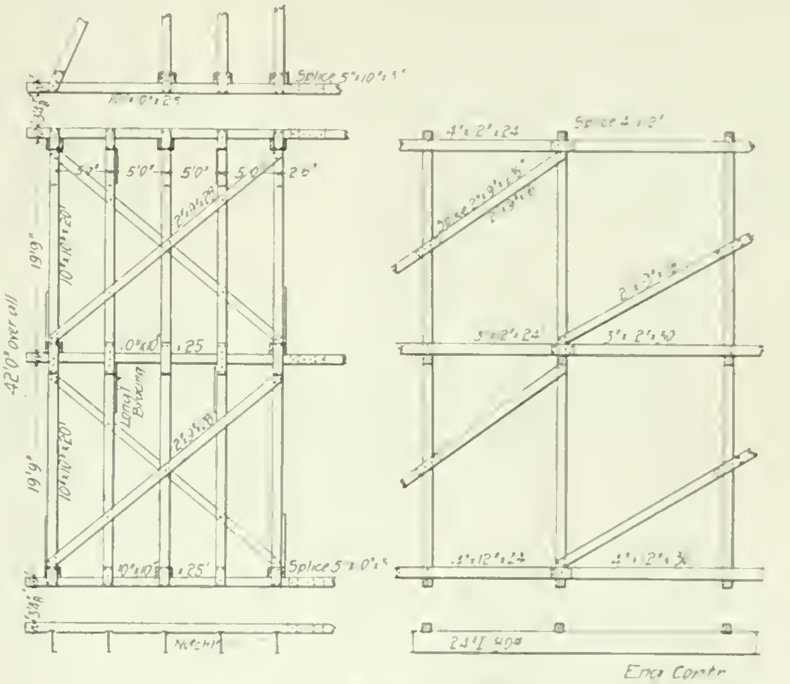

Fig. 3—Details of "Staging" Portion of Centering.

The horizontal strains developed in the centering were provided for by introducing in the framing 3 x 12-in. and 4 x 12-in. horizintal timbers at different elevations, where they would be most effective in maintaining the proper equilibrium horizontally, of the arch rib during its various stages of construction; these timbers were continuous from end to end of the horizontal elevation at which they were placed and were thoroughly spliced, butt jointed, and connected to the vertical trestle bents throughout their length, serving also as a longitudinal tie between the trestle bents themselves. Usually the framing is so arranged that the horizontal strains developed are resisted by inclined posts mortised into the verticals, but in the present centering we remark the entire absence of such timbers, and in their place horizontal timbers were provided having a definite action which would be more effective than if inclined; generally horizontal string pieces are used, acting simply as string pieces in conjunction with the inclined struts, but in the present case entire reliance was placed in the direct acting horizontal timbers as being most effective; the present centering is believed to be the first where this principle was rigorously adhered to.

There were two spaces of about 1 ft. each left for adjustment at each point of support, the lower one between the floor of the steel trestle and the staging, and the upper one between the staging and the upper trestle. The upper one was used for adjusting, by means of jacks and wedges, to proper height and for releasing when desired, while the lower one was added mainly for emergency use, though, fortunately, it was not required at any time; after the centering was erected true to line and height, the whole centering was still further raised to about 2½ ins. above normal height at the crown, gradually diminishing to zero at the skewbacks; this was to allow for settlement of the centering under the weight of the arch rib. At the completion of the final keying of the masonry of the arch rib, it was found that the soffit of the centering at the crown had finally settled to 1 in. below normal height, making a total settlement of the centering of 3½ ins. at the crown; this measurement was taken at the time the centering was removed.

A feature of great interest will be found in the manner of supporting the lagging, which forms simply a platform upon which the masonry of the arch is formed during its construction. This platform can be formed in several ways upon the vertical supports of the falsework itself, but in the present case it was thought best to frame the platform so that each vertical support would carry its own load without any connection with adjacent supports; there is therefore in each span a series of joists laid parallel to the span of the arch and extending only from one support to the next support, and upon these joists the lagging is laid. In the framing of these joists they presented an opportunity of utilizing them as a continuous compressive member, which, following the lines of the intrados of the arch from end to end, would assist the centering to that extent, and while this assistance was more or less indeterminate, yet it was made use of; to secure such combined action of these joists in continuous compression, they were not jointed end to end in a butt joint bearing, but each series of joists was united to the next series by 3 in. oak tree-nails 2 ft. 6 ins. long, the holes for which were accurately bored to templet, thus insuring effectiveness in action and accuracy in profile. This method of utilizing the joists in continuous compression is believed to have been used for the first time in the present centering.

Having described in detail each vital feature in the design with the steps leading to the adoption of each, we may take up the more technical part relating to the proportioning of the various parts.

The unit strains allowed in timber and steel were the usual ones allowed for permanent work; no reduction was made on these, for the reason that the centering had not only to serve for the construction of one arch rib, but had also to serve, under deteriorated conditions, for the second arch rib, and the whole service covering a period of about a year; besides it was necessary to allow for inequalities of distribution in the weights borne, so that these unit strains could withstand an increase of 50 per cent. upon the normal strain should this contingency agency arise, and yet be safe.

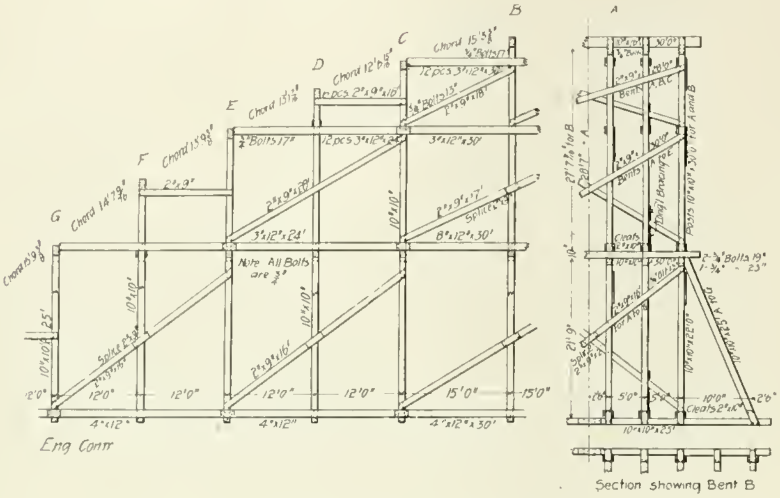

Fig. 4—Details of "Upper Trestle" Portion of Centering.

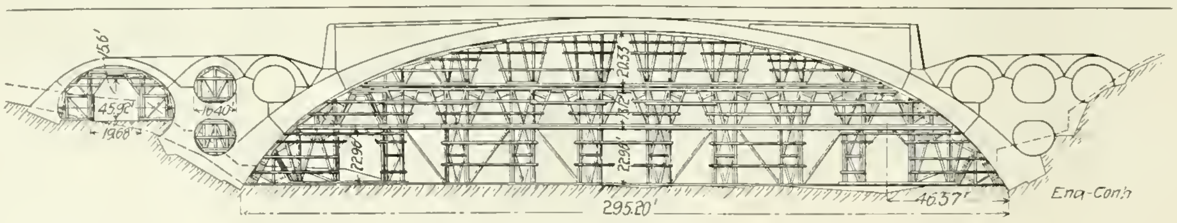

Fig. 5—Centering for the Plauen Stone Arch Bridge.

The folowing unit strains were used:

For yellow pine timber, beams 1,200 lbs. per sq. in. on extreme fiber;

posts, $1{,}200 \div (1 + \frac{L^2}{1{,}200\,D^2})$ lbs. per sq. in.

For structural steel, beams 16,000 lbs. per sq. in. on extreme fiber;

posts, $12{,}000 \div (1 + \frac{L^2}{36{,}000\,r^2})$ lbs. per sq. in.

Rollers $400\sqrt{d}$ lbs. per lin. in.

In above formulas L is the length, D is the side, r is the radius of gyration, and d is the diameter—all dimensions being in inches.

The completion of any arch masonry and the release of its centering are always matters of great interest, both in regard to the arch and also in regard to the manner of release and the consequent action of the arch and centering individually; it is always a critical time and a period of prime importance. In the present case the masonry of the first rib was required to remain on the centering for a period of at least one month after the final keying, after which the centering was allowed to be released and removed into position for the construction of the second rib. In releasing the centering the wedges at the skewbacks were first made entirely clear in order to prevent the arching or binding of the lagging at the haunch ends against the arch rib; after this, the whole system of wedges at the base of the upper trestle was slightly lowered in continuous succession, beginning at the center and advancing outwardly, and simultaneously each way to the skewbacks; after this was done, the operation was repeated in the same manner, making each separate point entirely clear of the arch rib from the center each way to the ends. This system of release was thought to be most proper in accomplishing the desired object of gradually causing the arch rib to assume and perform its proper function in its entirety. Upon the complete release of the centering it was found by means of leveling instruments trained on targets placed at various points on the face of the arch rib, that the crown settled but ⅛ in. (after the support of the centering was entirely removed).

It is well to state that the nature of the design was such as to allow of its fabrica-

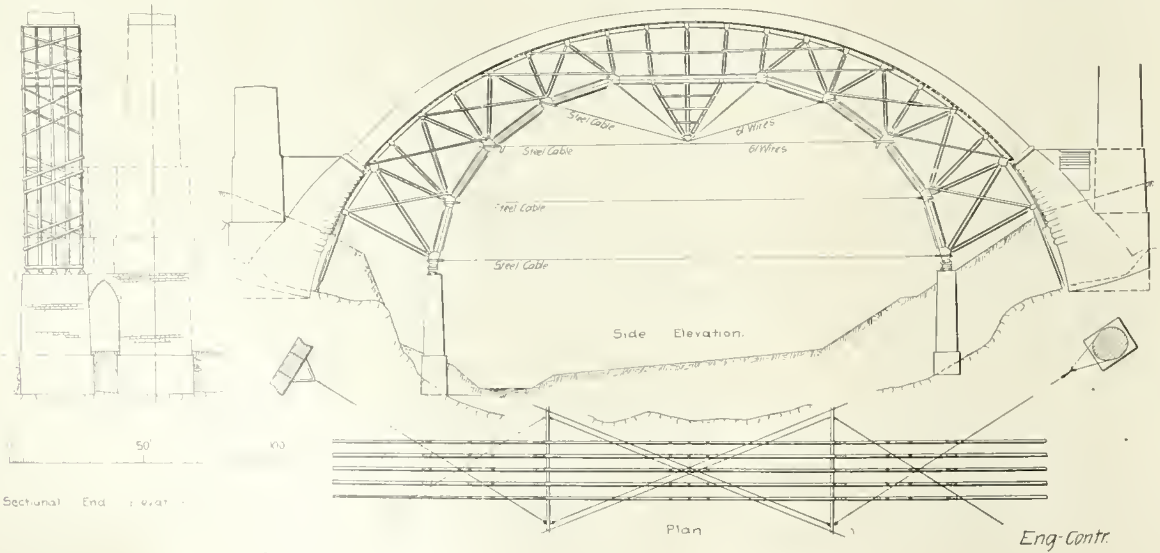

Fig. 6—Centering for the Luxemburg Stone Arch Bridge.

tion on the site by the contractor. This is thought to be an important item financially. The style of the construction, while effective, was in the main essentially simple, no intricate features were involved, and the workmanship demanded, while being accurate, was still made simple by means of templets, which, being made in multiple parts, thereby reduced the unit of cost. In short, every effort was made to make the design not only effective and successful as an engineering problem, but equally so as a financial one; the work, it is believed, has accomplished both.

It may be of interest to state the quantities of material used in the construction of the centering, and, for a comparative item, that the concrete in one arch rib amounted to 1,550 cu. yds.

Bolts, washers, nails	33,000 lbs.
Steel trestle and its floor	232,000 lbs.
Lagging and joists	88,000 ft. B. M.
Upper trestle and bracing	116,000 ft. B. M.
Lower staging and bracing	136,000 ft. B. M.
Concrete piers	1,000 c.y.

Comparative Data.—It is a noteworthy fact that engineering literature is peculiarly deficient in data regarding the centering of arches, and it is therefore difficult to compare one design with another, even though there may be some general features in common. This can only be realized when actually engaged in such inquiry; in the first and main case the data is not readily accessible, and even when made so, it is so limited as to afford little assistance, and in general it may be fairly stated that the contingent circumstances in each case are so various as almost to forbid any generalization.

Plauen Stone Arch Bridge.—In the centering of the Plauen Stone Arch Bridge, span 295.27 ft., rise 56.41 ft., Fig. 5, it is stated that 1 cubic unit of timber was used for every 2 cubic units of masonry; therefore, taking this as a guide, we find that the Plauen centering was quite shallow, and extended only to springing line; also that the arch ring was built up in its complete depth in one operation, and so requiring the full support of the centering until final keying; therefore with this data we can make a fair comparison with the present Walnut Lane centering, for both have to maintain the full support of the arch until keying, and they differ only in height of centering; therefore, making the proper allowance for this feature in the Walnut Lane centering, we find less timber required in it than in the Plauen arch; 5-6 cubic unit of timber was required for every 2 cubic units of masonry as shown below.

Taking the data from the summary of quantities:

Lagging and joists—

$$88{,}000 \text{ ft. B. M.} \times 1 = 88{,}000 \text{ ft. B. M.}$$

Trestle and bracing—

$$116{,}000 \text{ ft. B. M.} \times \frac{70.25}{54.63} = 149{,}000 \text{ ft. B. M.}$$

$$237{,}000$$

This gives an item of 237,000 ft. B. M. for a height of 70.25 ft. Now, in order to make a comparison with the Plauen centering, the vertical trestle item of 149,000 ft. B. M. should be reduced by the ratio $\frac{56.41}{70.25}$, making it 119,700 ft. B. M., which, with the item of 88,000 ft. B. M. for lagging, makes a total of 207,700 ft. B. M., or 640 cu. yds. timber for 1,550 cu. yds. masonry, or 1 cubic unit of timber to each 2.42 cubic units of masonry, or 5-6 cubic unit of timber to each 2 cubic units of masonry.

Luxemburg Stone Arch Bridge.—In the centering of the Luxemburg Stone Arch Bridge, span, 236.16 ft., rise 53.23 ft., Fig. 6, we find an arch of two ribs similar to that of Walnut Lane, but the radical difference is in the manner of forming the arch ring, which was to divide the depth of the arch into three rings and to erect and key one ring at a time, a method applicable to stone arches, but not so applicable to concrete arches. This method of erection manifestly allowed a lighter centering than otherwise, for the completion and keying up of the first ring made it assist the center in carrying the second, and the second ring when completed also assisted the center, together with the first ring, in carrying the third ring until its completion; therefore, as regards the strength of the center it appears fair to consider it as being built with sufficient strength to support two rings until the final keying of the second ring; the amount of masonry therefore carried by the center being two-thirds of the whole complete arch.

In order to effect a comparison between the Luxemburg and Walnut Lane centerings it was thought that means could be obtained by evaluating the summary of quantities in each case according to the quality of work and material, and thus obtain a comparative ratio by means of the total values for the amount of masonry carried; this is shown below:

Luxemburg:

Timber	145,000 ft. B. M	at $80.00	$11,600
Metal	157,000 lbs.	.06	9,420
Masonry	480 c.y	7.50	3,600
			$21,620

In one arch rib 1,110 c.y. masonry

Walnut Lane:

Timber	340,000 ft. B. M	at $65.00	$22,100
Metal	265,000 lbs	.04	10,600
Masonry	1,000 c.y	10.00	10,000
			$42,700

In one arch rib, 1,550 c.y. masonry.

If we assume that the Luxemburg centering carried two rings until final keying, which would mean two-thirds of the total arch rib, then to carry the three rings would be 50 per cent more; therefore we have

$24,620 + $12,310 = $36,930 for 2,220 cu. yds. masonry = $16.65 per cu. yd. masonry. And for the Walnut Lane centering we have

$42,700 for 3,100 cu. yds. masonry = $13.80 per cu. yd. masonry.

Or the centering of the type of Walnut Lane costs 5-6 of the cost of centering of the type of Luxemburg; and in this connection it is well to note that the value of the above ratio obtained will not be appreciably changed by using other comparative units of value for work and materials than those assumed above.

Further information regarding the premature explosion of dynamite Dec. 12 at Bas Obispo on the Isthmian Canal is given in the Canal Record of Dec. 16. Up to now, Dec. 15, 19 men were dead, 40 were more or less injured and several were missing as the result of the explosion. The accident occurred at 11:10 o'clock when the men were leaving for their noonday meal. Fifty-two holes had been loaded. The cause of the explosion can only be conjectured. It was intended to set off a blast of 53 holes containing 11,000 lbs. of 45 per cent dynamite shortly after 5 p. m., Dec. 12. The last of the holes sprung had been cooling for at least two days before the dynamite was placed in them. The charges had been tamped in and fuses set in all but one of the holes. One gang was tamping the last hole, and the powder foreman, Benjamin H. Cole, was personally supervising the work. A negro who was sitting on the ground beside the hole directing the movement of the wooden tamping stick, was almost buried by the explosion, but was uninjured. Mr. Cole was seriously injured, but was able to make a statement immediately after the accident. He said that the explosion did not begin in the hole where the tamping was being done; that none of the holes had been wired, and that he could give no reason for the premature blast. The charges were to have been set off by electric current, supplied from the Empire power plant. The wires had not been strung, no two of the holes had been joined, as the firing is done in parallel and not in series, and furthermore the dynamos at Empire were out of service at the time the accident occurred. It was a clear day and there was no lightning to which the explosion could be ascribed. Men who were in the cut at the time say that there were two distinct explosions, one at the north end of the section that had been loaded, and another at the south end. The part of the cut that had been loaded for the blast was the west bank, and the holes extended a distance of about 200 yds. along the cut going down 50 ft. through solid rock. Below the level of the rock it was proposed to displace, four steam shovel cuts had been made at varying depths, one of them being almost at grade. The explosion threw a mass of rock, which is estimated at 55,000 to 60,000 cu. yds., onto these lower levels, completely filling the lowest three cuts, and piling the rock from 20 to 30 ft. higher over the lowest channel.

Railway Section

Note: This section is devoted to methods and costs of constructing railways. It will cover road-bed and track construction, contractor's plant and organization, surveying methods and permanent way structures.

Comments on the Manufacture and Use of Steel Rails.[*]

BY FRANKLIN E. ABBOTT.[†]

The writer will endeavor to outline in the simplest possible manner a description of the process of manufacturing steel rails, starting at the source of supply of raw materials, showing how they are brought together to begin the process by making iron.

It should also be kept in mind that this description will be limited to the making of Bessemer steel for the manufacture of rails as now used.

All reference to rolling mills will imply the mills of the Lackawanna Steel Co. in this immediate vicinity, which some have already seen and which you are all invited to visit at any time.

Ores used at the Buffalo steel plant come from Pennsylvania, Northern Michigan, Wisconsin and Minnesota, with the Northern ores in predominance.

Statistics of iron ore mining show that fully two-thirds of all rail steel made in the United States come from Messebe ores.

Deep ore mining is a subject of great interest and a full description of the plans and methods by which it is carried on would require as much time as we propose to give the whole subject before us today. But the mining of Messebe ores is a simple process, and being visible to the observer from the ground surface, a brief description can be readily made and easily understood.

These mines are unique in every respect. In the first place the ore beds are only a shallow depth below the ground surface. This depth will vary, but in mines now being worked, maximum will probably not exceed 50 to 60 ft. The body of earth, covering the ore, is composed mainly of gravel and boulders, which is stripped from the top of the ore beds by ordinary methods of moving dirt in railroad construction.

When the ore is uncovered, the process of mining by steam shovels begins. This is carried on somewhat on the plan of excavating a gravel pit. A long trench is started, and as the depth increases, switchback tracks are laid so that a workable track grade can be maintained. Another plan followed is to start excavating the mine circularly; that is, in a sense, boring a hole in the earth's surface anywhere from a quarter to one-half mile in diameter. Steam shovels are worked inside of a circular pit, cutting away at a depth of face most easily handled. Tracks over which ore cars are operated are laid in form of a spiral to maximum curves and grade most practicable.

Ore dump cars are loaded direct by the steam shovel. They are then forwarded to the ore docks at Duluth and Superior, weighed as they go on the docks, without stopping the continuous motion of the train, and dumped into large pockets. Having weighed the carloads, the exact quantity of ore in every pocket is known.

From these pockets the ore is drawn directly into boats. Some handwork is necessary to properly trim the vessels, but the loading is done almost entirely through chutes, which distributes the ore quite evenly and very rapidly.

A record of loading ore—1,200 tons in 90 minutes—has been made. When the loaded boats reach their destination at the steel plant docks, the ore is discharged by self-filling clam shell buckets and finally reaches the piles at the blast furnaces. Thus the ore is moved with scarcely any handwork direct from its native bed to the furnace, where it is finally reduced to pig iron.

A detailed description of the process of making iron is hardly pertinent at this juncture. Suffice it to say that the ore is charged into the furnaces at the top with proper proportion of cake and limestone, and the result is the pig iron tapped out at the base of the furnace every time the hearth gets full.

Making steel by the direct process consists in taking molten iron direct from the blast furnaces to the steel plant and continuing it through the operation without ever becoming solidified till finished.

The iron is taken from the furnace in ladles holding about 20 tons, from which it is poured into a large mixer holding about 200 tons. The object of the mixer is to make a better average composition of iron, and hence a more uniform grade of steel.

From this large vessel, or mixer, the iron is drawn into a ladle holding about 10 tons, and from this charged into the converter, when the process of steel-making begins.

The converter consists of a steel shell mounted on trunnions, supported on pedestals so that a semirotary motion may be given The tuyeres, or special-shaped perforated fire bricks, are placed at the bottom of the vessel. Below the tuyeres is an air chamber which receives the blast of air through one of the trunnions, which is hollow and acts as a blast main. On the other trunnion the requisite turning gear is fixed.

When ready for a molten charge, the vessel is turned on its axis into a horizontal position and the melted iron poured in. The requisite weight of metal does not reach the tuyeres while in that position. The air blast is admitted into the chambers at the base of the vessel and is forced through the perforation in tuyeres into the vessel. After the blast is admitted, the vessel is returned to a vertical position and oxidation of impurities in the iron begins immediately.

The pressure of the blast, 20 to 25 lbs. per sq. in., prevents any metal entering the tuyeres. The blowing of the iron in the converters sets up reactions which result in decarbonization, and also burns out silicon and manganese, but sulphur and phosphorus originally in the iron will remain after the blowing, and in slightly increased percentage, owing to reduction of the original volume of oxidation. The blowing takes from 10 to 20 minutes, depending on the quality of iron, and a skillful operator can tell when the metal has been sufficiently burned out by the color and dropping of the flame, when the vessel is immediately returned to a horizontal position.

The content of the vessel at this stage is nearly pure iron.

While the molten iron is still in the vessel, a quantity of other molten metal called spiegeleisen, containing a known quantity of iron, carbon, manganese and silicon, is poured into the vessel and is immediately diffused through the whole mass; thus iron is changed into what is known as Bessemer steel.

The steel is then poured from the vessel into a ladle, and from that tapped out into ingot molds in which it is left to solidify.

The ingot molds are cast-iron boxes, open at both ends, averaging about 18 ins. square, but tapering outwardly toward the base. The ingots are cast with these molds standing upright on heavy cast-iron table cars, the car tops serving as bottoms to the molds. They are then moved forward on these cars from the steel plant to the stripper.

The stripper consists of a powerful horizontal electrical crane, equipped with a combination of lifters and plunger. The ingot molds are grappled by enormous links automatically hooked into ears or lugs at the end of the molds, made for that purpose, and as the ingot mold is raised the plunger comes down, forcing the ingot from the mold through the open bottom, leaving it standing upirght on its own base on the car.

With the ingot thus cast and the mold stripped from it, the process of steel-making is completed.

The red-hot ingots are then forwarded, still standing on the same iron cars, to the rail mill, where they are deposited in reheating furnaces called "soaking pits" and left there till brought to proper temperature for rolling.

Placing ingots in the soaking pits is substantially the beginning of rail-making. But before passing to that step in the description it will be of interest to understand as well as possible the behavior of the steel and what takes place when it passes from a liquid to a solid state.

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[*] A paper delivered before the Central Railway Club.

[†] Chief Inspecting Engineer, Lackawanna Steel Co.

When the liquid or molten metal comes in contact with the cold iron of the mold, it immediately freezes at the sides and base and gradually toward the center. The *interior* is the last to cool, and the part of *that* last to cool will be at the top.

The wide contraction that the metal undergoes in passing from molten to a solid state makes a very considerable reduction or shrinkage in its volume. As the top of the ingot is the last to solidify, the drawing in of the mass will concentrate at that place, and there is formed a cavity or honeycombed part, extending a few inches down. This opening or unsoundness at the top of the ingot is known as piping.

Another peculiarity that develops when steel passes from liquid to solid is segregation of some of its constituent elements, especially carbon, sulphur and phosphorus.

The term segregation when used in connection with the metallurgical characteristics of molten steel must be understood as the drawing away from one part of the mass to another of such elements as will separate before the steel freezes or becomes solid.

Segregation apparently proceeds in the same way that the steel solidifies. It works from the outer parts toward the center, and there will be the greatest concentration of the segregated elements at the top of the ingot where the metal is last to cool. There is found in this part not only the piping and spongy mass, but the part of the steel made inferior by an overload of carbon and probably manganese and also excessive sulphur and phosphorus. This inferior steel is discarded, as will be seen further along.

Keeping in mind then the shape and condition of the steel in the ingot, we will take up the second step, that of making ingots into rails.

As already noted, the ingots are placed in the soaking pits, always in a vertical position, where they remain from 90 to 150 minutes, in order to be brought to proper temperature for rolling.

This heat treatment in the soaking pits results in lowering the temperature at the center of the ingots, which may at times of charging be nearly, fluid, and raising the temperature of the outer part, which at the same time may be solid and reduced to cherry red. The whole mass is thus brought close to a uniform and approximately plastic condition, which makes it fit for the rolling process

The reheated ingot is then taken from the pit, placed on an electric conveyor and rushed forward to the mill, where it is turned down on its side preparatory to entering the rolls. This is the first and only time an ingot lies in a horizontal position during the whole process of making and reheating the steel.

It may be well to note here the great advantage gained by both makers and users of steel rails in this modern practice of always keeping ingots in a vertical position, from the time they are cast till the metal has been brought to proper consistency for rolling.

In nearly all specifications for steel rails, there is a short clause which reads about as follows: "No bled ingots shall be used."

This restriction, so much needed in old methods, is of little or no account at the present time.

In the early days of rail making it was the practice to throw ingots on their sides as soon as they were taken from the molds, and, in fact, they were kept in that position in the reheating furnaces. If, by chance, the surface crust at the ends should break open, the fluid metal at the center of the mass would bleed out, leaving a hole which would almost certainly result in piped rails.

The longer time given under the present practice for the metal to solidify in the molds, and always keeping the ingots in a vertical position in the reheating furnaces, practically eliminates all possibilities of any bleeding, and in a corresponding degree makes a protection against getting piped rails in the product.

When the ingot is turned down on its sides for the first time, it enters the blooming rolls. The first two passes are through two separate sets of rolls of large diameter, operated by powerful engines. The motion is slow, and the reduction heavy. It then moves forward to the next set of rolls, where four passes are made, and a bloom of about 8x8 ins., 20 to 22 ft. long is completed.

In these shapes the size of the bar is reduced sufficiently so that the ends can be sheared off. Enough metal is cut from the end coming from the top of the ingot to remove all traces of piping or spongy steel, and also removes the part containing greatest amount of segregation. From the other end, coming from the *bottom* of the ingot, enough is cut off to make the end face square and solid. After the shearing, the bloom is conveyed to the roughing rolls where in four passes a rough form of the rail section is worked out From there the bar goes to the finishing rolls, making four more passes, thence moved sidewise across the mill floor to the last finishing pass, where the rail section is finally completed to the minute refinement of its detailed dimensions.

The block of steel which started at the other end of the mill, about 18 ins square and 50 ins. long, has now become a rail with a sectional area 6 or 7 sq ins. and 175 ft. in length. All this change has been made in an interval of eight to nine minutes.

In a two-high mill, such as the one referred to in this paper, the ingot is continued throughout the entire rolling process in one piece, and finally a single length is furnished equal to four or five 33-ft. rails

The long rail is carried from the last finishing pass to the hot saw, where it is cut into standard lengths, according to order, cutting one rail at a time, thence through the cambering rolls to the cooling beds, where the rails are left till brought to the temperature of the atmosphere or about seventy degrees.

In passing through the cambering rolls the rails are forced into a curvature with the head arching upwardly That is to say, if the rail, immediately after coming out of these rolls, were made to rest on its base, or in the track-man's parlance, "work ways," the ends would be low From this shape it warps first to the opposite curvature, bringing the ends high, then back toward the first shape and finally drawing back again in the final cooling, leaving the rail, when resting freely, on its base with a back sweep or the ends up.

The effort on part of the mill superintendent is to regulate the cambering so that the rails will cool as nearly straight as practicable, but as absolute straightness is almost impossible to attain, they are preferably brought, when cold, to a slight back sweep as already described

There are two reasons for having rails at their normally cold temperature with back sweep rather than head sweep, if they do not come out perfectly straight.

First—The cold straightening work will be done mainly on the base, thereby escaping the danger of indentations from gaging iron on the running surface of the head

Second—The internal stresses left in the rail when it becomes cold, tending to draw the ends upward, even after it is cold straightened, will help to hold the joints up and maintain better track surface when the rails are put into use

The rails pass from the cooling beds over live rolls, by which they are distributed to the presses where they are straightened, drilled, finished and inspected, thence they are carried down through the mill to the loading sheds, and finally placed on cars.

This completes a general outline description as to how rails are made

But before going on with the third step, the use of steel rails, it may be of interest to return to some points along the process of rail making where greatest difficulties are encountered, and also cite some of the articles in standard specifications that are a source of more or less contention between the makers and users

One such article is that covering chemical compound When the spiegeleisen is poured into the purified iron in the vessel just after the blow, necessary ingredients are introduced to make it hard, elastic and ductile

Chemical analyses of average Bessemer

rail steel as made at present for heavy rails run about as follows:

	Per Cent.
Carbon	.50
Phosphorus	.10
Sulphur	.08
Silicon	.12
Manganese	1.00
Iron	98.20
	100.00

The quantity of carbon can be controlled by the grade of spiegel used. The makers and users of rails are not exactly agreed as to what the limits in carbon should be. The users have been inclined to increase carbon content somewhat faster in proportion than the increase in weight of rails. When a 70-lb. rail was regarded as a heavy section, carbon, in the steel, ran from 0.35 to 0.40, but when the weight of rails reached 100 lbs. per yard, 0.60 per cent carbon was called for and in some cases the upper limit was fixed at 0.65 per cent. The higher carbon steel, 0.55 per cent to 0.65 per cent, was also specified for lighter rails such as 880-lb. and 85-lb. per yard. The 80-lb. rail was an increase in weight of only about 14 per cent over the 70-lb., but 0.58 per cent carbon often called for in this weight rail was an increase of fully 45 per cent of this element over the lighter section. It can be seen that hardening properties were raised entirely out of proportion with the increased weight, and the apparent consequence was a less satisfactory rail in the heavier section.

The reason for raising the carbon was to get more elasticity and better wear, which in a degree was obtained, but with it came more failures from breakage. It was then proposed and specified on part of the users that phosphorus should be lowered about 15 per cent, making the limit not to exceed .085 per cent. This proposition seemed entirely consistent from a metallurgical and theoretical standpoint, but practically it cannot be obtained because of the ore conditions.

It is estimated that the available 0.085 phosphorus Bessemer ores in the United States are relatively small.

If all the rail mills in this country were to undertake to fill, from American ores, the annual requrement of about 3,000,000 tons under .085 phosphorus specifications for Bessemer rail steel, that grade ore would be exhausted before provisions could be made to meet the yearly demand for rails made by any other process.

If open hearth steel is to succeed Bessemer, it will take a term of years and the expenditure of an enormous sum of money to build furnaces enough to provide the steel needed for rails alone. Before this could be accomplished it is more than probable that the .085 phosphorus Bessemer ores would run out, and with an inadequate production of open hearth steel, the rail roads would have to either get along with a short supply, or import the tonnage lacking. In the event of such sources not being able to keep pace with the demands, their only alternative would be to take a grade of Bessemer steel far inferior in wearing qualitties to what they are now getting.

To avoid this apparent short cut to the end of good quality Bessemer rail steel, the makers insist that the phosphorus limit shall be left as it has been for a number of years past, at .10 per cent, and a somewhat modified carbon content be used.

It is entirely practicable to use enough carbon with .10 per cent phosphorus ores to make perfectly sound, safe and serviceable Bessemer steel, and with that limit accepted, the manufacturers will be able to produce good quality Bessemer steel rails for many years to come.

The wear of the heavier section rails has not been all that the users expected, even with the proportionally higher carbon, and they are loath to make any recession in this hardening element, fearing that by so doing, there will still be greater loss from rapid wear. But the question of safety must have first consideration, and neither the makers nor users of rails will be justified in adding hardening properties, to get increased service, that will place the material anywhere near the danger line of breakage.

So the question of carbon and phosphorus content that shall be used in Bessemer steel for rails is not fully and definitely settled. The phosphorus limit is substantially fixed by conditions. The carbon limit to correspond is likely to be fixed by more experience.

There is a strong probability, however, that harder steel may be used if the shape of the rails is changed. How this may be brought about will be considered further on.

The next element in order in the steel composition is sulphur. This is of little consequence to the user of rails. Its effect is to make hot steel dry, or what is called "hot short," and liable to pull apart, making flaws on the surface of rolled shapes. A limit of .10 per cent can be handled very well, but it is always to the interest of the manufacturer that it should be lower.

Silicon has a quieting influence in molten steel when it is settling and cooling in the molds and makes it dense when cold. A limit of .20 per cent is generally stated in specifications.

The quantity of manganese in rail steel will run from .80 per cent to 1.10 per cent. Its effect is to make the hot steel tougher, overcoming some of the bad effects of sulphur, and thereby better adapted to rolling. It also makes the steel harder and better for wear, but if the quantity exceeds very much the upper limit noted it is liable to lead to brittleness.

Another clause in standard rail specifications that is a source of some contention between makers and buyers of rails, reads as follows: "Sufficient material shall be discarded from the top of the ingot to insure sound rails."

Under that agreement the buyers of rails can get, and do get, perfectly sound steel. The interpretation of the term sound in this case means entirely free from piping or spongy metal.

Sound steel rails of standard composition are perfectly safe to use, and when the railroad companies have exercised their rights given by the specifications in their inspection at the mills, while rails are being made, and thereby obtained sound rails, they have done their whole duty toward themselves and their patrons, whose safety and welfare they are bound to protect.

But the question arises why do the railroad people, or so many of them, come up with a demand for more discard, in some instances asking for a fixed amount not less than 25 per cent of the whole ingot. It is not a question of safety, but one of service. Under present specification, the rail mills must deliver to the railroads safe rails, that is to say, free from the danger that comes from piping. They are obtained by shearing from the top of the ingot sufficient material to insure sound steel.

Then what would the railroads gain by doubling the discard if 25 per cent should amount to that increase? They might get a larger percentage of better wearing rails than they now receive, but the gain would be purely in an economical sense, and not in one of safety. Therefore, the question of more discard after enough has been made to insure sound and safe rails is purely a commercial one, and can be disposed of between the railroads and the steel companies without giving cause for any anxiety on part of the public.

In addition to the discard sheared off the bloom, a crop end is cut off the long rail when it is finished, taken from the end toward the top of the ingot. This is about six feet long and is used for a drop test.

One such test piece is taken from every blow of steel. It is placed on steel wedge-shaped bearings, three to four feet apart, and struck with a 2,000-lb. weight, falling 15 to 20 ft. (depending on size of rail tested). Deflection of test piece under this drop is carefully noted and made a part of the inspection records. If the test piece breaks under the drop, all rails from blow represented by that test must be discarded.

This is the most satisfactory proof of the quality and strength of the rails that can be used. If the steel is brittle, it will be discovered by the character of the break. If piped, that condition can be seen in the fracture, and will determine at once whether or not sufficient discard has been made at the shears to insure sound steel. If the metal is very soft, it will show by excessive deflection It can be seen, therefore, that the drop test throws out many safeguards against passing deflective or inferior material.

(To be continued.)

Unclassified and General Articles

Note: This section is devoted to methods and cost articles on construction work not properly coming under any of the preceding classifications.

Methods and Cost of Placing Puddle in a Cofferdam by Pumping.

Mr. William Martin is authority for the following data:

In building Davis Island Dam, several years ago, a cofferdam 1,085 ft. long, containing 5,784 cu. yds. of puddle material, was built by pumping the puddle from an island. The cofferdam consisted of two rows of piles, the rows being 15½ ft. c. to c. and the piles in each row being 21 ft. c. to c. The piles were 20 ft. long, and were driven 8 ft. Three rows of wale pieces or stringers were bolted to the piles, 12 ft. apart. A single line of vertical sheeting plank, driven 2 ft. into the gravel bottom, rested against the wales. The joints of the sheeting were covered with 1x6 in. strips to prevent leakage of the puddle. On each side of the sheeting, at the top, was spiked a 2x10 in. string piece, to form a bearing upon which a plank deck was laid.

The plant, as finally developed, was as follows:

Tubular boiler, 36 ins. diam., x 16 ft. long.

Engine, 10x10 in.

Piston pump—steam cyl. 12x18 in.; water cyl. 6½x18 in.

Centrifugal pump, 3 in. discharge.

Pipes, etc., of the following sizes were used: Delivery pipe, 4-in.; clearing pipe, 2½-in.; priming pipe, 1½-in.; lubricator pipe, 1-in.; steam pipe to engine, 2½-in.; steam pipe to piston pump, 2-in.; band wheel on engine shaft, 4½ ft.; pulley on centrifugal pump shaft, 10 ins.; width of driving belt, 10 in.; agitator hose, 1½ ins.

The following pressures were obtained: steam boiler, 100 lbs. per sq. in.; gage on piston pump, 70 lbs.; gage on delivery pipe, 35 lbs.

The centrifugal pump for pumping the puddle was located on an island 900 ft. from the cofferdam. Beneath the pump was a tank for mixing the puddle, 8 ft. diameter and 4 ft. deep, sunk to a sufficient depth to secure a fall of water from a flume that tapped the river.

The piston pump was connected to the delivery pipe by a wye connection, and was used for priming the centrifugal pump, and keeping the sand from packing, and for furnishing water for the steam boiler and for the agitator hose, as hereafter described.

The puddle, consisting of loam and sand, was obtained within a radius of 100 ft. from the pump by loosening with a plow and delivering close to the tank with drag scrapers. It was then shoveled by hand into the tank, a cost that could have been avoided had the scrapers dumped through a trap into the tank. The material was mixed with water in the tank and kept agitated by water from a hose in the hands of workmen, to prevent the earth from settling to the bottom. This puddle was taken by the feed pipe of the centrifugal pump and forced through the delivery pipe to the cofferdam, a distance constantly increasing as the work progressed. The delivery pipe was laid on the bottom of the river, and then rose by an easy ascent to about 1 ft. above the top of the cofferdam.

The puddle occasionally became so thick as to clog the delivery pipe. In order to meet this difficulty, the following ingenious plan was devised. On the delivery pipe at the centrifugal pump was placed a pressure gage. Any clogging of the delivery pipe immediately caused the pressure to rise, whereupon the engineman slackened the speed of the centrifugal and opened the valve in the wye connection to the piston pump. This admitted a stream of clear water at high pressure from the piston pump and immediately cleared the congestion of puddle in the delivery pipe. The check valve in the delivery pipe between the wye connection and the centrifugal pump prevented a back flow into the centrifugal pump.

At the bottom of the feed pipe in the tank was a screen having 1-in. meshes. Above the screen, and in the same casing, was placed a foot valve for the purpose of holding the priming.

One of the principal difficulties in working the centrifugal pump was the rapid wear of all its parts that came in contact with the sand. The casing, which was originally ⅜-in. thick, wore through in 10 days, during which time not 2,500 cu. yds. of puddle were handled. This was replaced with a 1-in. casing which was still in service after the 13 days use which completed the job.

The stuffing box wore rapidly until the following ingenious device was applied: A screw was cut in the chamber in the opposite direction to the motion of the shaft. A pipe was put in back of the packing and connected with the piston pump. Water was forced through this around the shaft and, being under a greater pressure than the centrifugal pump, prevented the puddle material from getting into the stuffing box. Water thus applied performed a double duty, for it acted as a lubrication and prevented the shaft from heating.

At the discharge end of the delivery pipe the puddle material was deposited in the cofferdam and flowed off for a distance of a few hundred feet, depositing in a hard and solid mass. The loam being lighter, remained longer in suspension and settled out on top of the sand.

In 23 days there were delivered 5,784 cu. yds of puddle material, or 251 cu. yds. per 10-hr. day. Laborers received $1.75 to $2 a day, and mechanics $2.50 to $2.75. The cost was as follows:

Plant:	
Pump	$145
Repairs, fittings, etc.	382
Pipe	364
Total cost of plant	$891
Labor:	
Installing plant and pumping puddle, removing plant, etc	$2,847
Fuel:	
23 days fuel	$38
Total labor and fuel	$2,885

It will thus be seen that the cost of labor and fuel for puddling amounted to $265 per lin. ft. of coffer dam, or 50 cts. per cu. yd., including the labor cost of installing the plant. It is unfortunate that this item of installation and removal of plant was not kept separate, as it was evidently a large item. The fuel cost only $1.65 a day, or ⅔ ct. per cu. yd. The labor during the 23 days of pumping could probably not have exceeded 5 cts. per cu. yd. for pumping and pipe laying. With a haul averaging about 50 or 60 ft. for the drag scrapers, the cost of delivering the puddle alongside the tank probably did not exceed 10 cts. per cu. yd. Shoveling it into the tank doubtless cost less than 10 cts. per cu. yd. This would make a total of not more than 25 cts. per cu. yd. for the puddle in place, exclusive of plant charges for interest, depreciation, repairs and installation. Apparently the installation and removal of the pumping plant cost at least $1,500. The plant itself cost $891, as above given. The exceptionally high cost of installation appears to have been due in part to the experimenting incident to developing the best way of handling the material, most of which cost can be saved by studying the finally adopted methods and devices above given.

For comparative purposes it is well to add the following costs of filling another section of another cofferdam nearby by another method. The other section was 1,165 ft. long, and it cost $5.69 per lin. ft. for puddle in place, or practically $1.10 per cu. yd. of puddle. The method employed consisted in loading the material by hand into cars, hauling it over a narrow gage track to the river, loading into boats and transporting to the cofferdam, shoveling by hand into place, and compacting with water. Wages were only $1.25 a day for laborers and $2.25 for mechanics.

The production of primary spelter (crude metallic zinc) derived from ores in the United States in 1907, according to the Geological Survey, was 219,860 short tons, an advance of 11.2 per cent, and was the largest output in the history of the industry.

Using a "Skullcracker" and Lifting Magnet for Breaking up a Concrete and Masonry Foundation.

Drop hammer pile drivers have been used occasionally for breaking up concrete foundations and recently Mr. W. J. Newman, a Chicago contractor, has battered to pieces a heavy stone and concrete masonry foundation with a 10-ton iron ball lifted and let drop on the masonry by means of a lifting magnet. In tearing down the old Chicago City Hall a foundation consisting of a concrete footing about 3 ft. thick enclosing and carrying masonry pier footings had to be taken out to make ready for the foundation work of the new City Hall. Blasting was not desirable, owing to the site being surrounded by office buildings and stores and bordered on three sides by streets having a heavy traffic. To cut out the masonry and concrete mechanically meant a heavy cost and more time than could be afforded considering the contract time limits. The use of a "skullcracker," such as is used for breaking the "skulls" formed in steel furnaces, was the contractor's solution of the difficulty.

The experiment was first made with a pear-shaped ball weighing 8,250 lbs. This ball had a staple-shaped eye at its small end and was handled by a derrick having a hook-block which could be tripped by a tag line to let the ball drop. This arrangement worked well so far as breaking up the masonry was concerned, but it required about four men to trip the weight and much time was lost in attaching the hook owing to the ball falling so as to bury the eye and make it hard to get at. The idea of substituting a lifting magnet for the hook and eye connection suggested itself, since this device would "take hold" of the ball in whatever position it might lay after falling.

A 24-in. diameter, two-coil magnet made by the Browning Engineering Co., Cleveland, O., was used. This magnet had its lifting face concaved to give it a better contact with the ball, otherwise it was of the standard construction for its size. Such a magnet weighs 1,100 lbs. complete, and can be attached to the ordinary hook-block. The transmission cable, in this work, where ordinary stiff-leg derricks were used, ran along the derrick boom on small sheaves and was counter-weighted to take up the slack as the magnet was raised. The magnet was shifted from derrick to derrick as the prosecution of the work required.

Shortly after the adoption of the lifting magnet, a 5-ton spherical ball was received and used in connection with the pear-shaped ball. A smaller ball operated by a trip hook was also used for light work. These balls operated very successfully except in one particular. When dropped from a height great enough to do the most effective work flying chips broke nearby windows and endangered persons passing on the street. To do away with complaints of these kinds the drop was reduced to from 15 to 20 ft., at which heights it was often necessary to drop the ball twice or three times to break through a heavy footing. Where trouble from flying chips would not interfere, the success of the method, we are informed, would be unquestionable.

LETTERS TO THE EDITORS.

Why California Is Ten Years Ahead of the Rest of the World in the Science of Building Dustless Roads.

Sirs: It is extremely interesting to read the articles published in the different engineering magazines, pertaining to highway improvement, in which the matter of the usages of bituminous products, or road oil is the principal feature. It is also ludicrous to one who has had any amount of experience in road construction in California, to read of the experiments with oils which are being made by Eastern road builders.

I have recently returned from a four month's trip throughout the East, and during that time visited most of the cities of any consequence throughout the United States. After having inspected a great many miles of highway, I have confirmed my opinion that Eastern road builders are at least ten years behind California in the matter of highway construction, especially in the use of oils in road work. The Eastern road builders are going through the experimental stage, which was started in California not less than 12 or 14 years ago. Since 1898 there has been a continued improvement in the use of the road oil (properly speaking, it is liquid asphalt), and for the past four or five years the Western road builders have reached a high standard of road construction.

In my extended inspection of Eastern roads (a good many miles of which I built in New York State ten or twelve years ago), I did not see any form of macadam roads which can equal the California macadam or oil macadam roads, and the most striking and important observation was that no form of macadam construction which I have seen East or West can compare with the improved method of asphaltic oil road construction where the proper kind of liquid asphalt has been used, and scientifically incorporated with the natural soil with a small amount of gravel or crushed rock for a wearing coat.

This California method has been used for the past eight or ten years at least, and the last two years have seen wonderful improvements in this method which has practically been perfected, and which certainly has stepped to the fore rank, and placed macadam in any form, in the back ground. This statement may seem broad, but I make it without fear of dispute, when any experienced road builder sees this class of work.

At Rye, N. Y., about 6,000 lin. ft. of work was done last summer under this improved form of road construction, which is known as petrolithic pavement. The excellence of the work at Rye is astonishing, particularly when the low cost of the same is considered.

It would be advisable for road builders to spend a few hundred dollars and take a trip to California, rather than spend thousands of dollars experimenting with road oils, for they can profit greatly by the years of experience of the California engineers.

I dare say if an engineer wanted a new transit or level, he wouldn't try to make one himself; he would go to the manufacturers who have perfected these instruments. If he could make an improvement on the instrument, once he had it, well and good The same is true with road building. It is a fact that California leads the world in highway construction.

If the world's congress of Good Roads had been held in Los Angeles, many engineers attending it would have learned more in one day about actual construction of modern dustless roads than they learned during the entire time at Paris listening to what the other engineer had to say about what he thought could be done.

G. A. W.

South Pasadena, Cal., Dec. 2, 1908.

Lime Barrel Forms for a Concrete Culvert.

Sirs: In a recent issue of your excellent publication (Dec. 16, 1908) I noticed an article describing a wooden form for small concrete culverts. On one occasion, I remember, I had to build a concrete culvert over a ditch, and having nothing at hand to make a form for the "bore" (about 18 ins.), I braced up several empty lime barrels and placed them end to end and built over them. After the concrete had set I punched out the heads of the barrels and left the sides to rot out in place. It is surprising how much weight a barrel so treated will support. Very truly,

Chas. L. Wood, C. E.

Columbus, Miss., Dec. 27, 1908.

The production of gold in fine ounces in the United States by periods from 1792 to 1907, according to figures of the U. S. Geological Survey, was as follows:

	Fine ounces.	Value.
1792-1847.......	1,187,170	$ 24,537,000
1848-1872.......	58,279,778	1,204,750,000
1873-1907.......	84,258,891	1,741,784,000
Total.......	143,725,839	$2,971,071,000

At the end of the year 1906-7 the Government of India had spent $158,147,128 on irrigation work since the scheme was started 50 years ago.

Engineering-Contracting Monthly Review Index of Civil Engineering Literature.

A classified index and review of the civil engineering papers, articles, reports, pamphlets and books published during the month just passed is given in the succeeding pages. The literature indexed and reviewed—with the exception of books—relates solely to civil engineering. In the section devoted to Book Reviews all books in all branches of engineering are listed as received and such of them as seem worthy are reviewed as fully as due regard for conciseness will permit. In choosing books for review rigid selection is exercised. Next to careful choice of books for review timeliness of review is sought. All books are reviewed within a month of their receipt. The same statement is true of the articles and papers that are indexed. Also, as in choosing books for review, the choice of articles and papers for indexing is based on merit. Numerical strength in "titles indexed" is not sought; excellence of selection is sought.

The purposes of the Monthly Review Index are: first, to inform civil engineers and contractors of the articles and papers of merit that are published each month, in such a way as will give a clear idea of their character and scope; second, to supply the user with the date and place of publication, the length of each article and the cost at which it can be secured. The name, adopted abbreviations, place of publication and price per number of each periodical examined for civil engineering articles are given in the list immediately following. The other information is given in the index proper for each article separately.

Books reviewed will be sent post paid on receipt of price by the Book Department of ENGINEERING-CONTRACTING, periodicals, etc., containing articles indexed should be ordered direct from the publishers.

LIST OF PERIODICALS INDEXED.

American Architect (Am. Arch.), New York, N. Y., w, 7x10 in., 15 cts.

American Builders' Review (Am. Bldrs. Rev.), San Francisco, Cal., m; 7x10 in.; 50 cts.

American Carpenter and Builder (Am. Car. & Bldr.), Chicago, Ill., New York, N. Y.; m; 7x10 in., 20 cts.

American Engineer and R. R. Journal (Am. Engr. & R. R. Jl.), York, N. Y.; m; 7x10 in.; 20 cts.

American Gas Light Journal (Am. G. L. Jl.), New York; N. Y.; w; 10x13 in.; 10 cts.

American Institute of Electrical Engineers Proceedings (Am. I. of E. E. Proc.), New York, N. Y.; m; 4x7 in.; 50 cts.

American Machinist (Am. Mchst.), New York; w; 7x10 in.; 15 cts.

American Society of Civil Engineers Proceedings (Am. Soc. C. E. Proc.), New York, N. Y.; m; 4x7 in.; 75 cts.

American Society of Mechanical Engineers Proceedings (Am. Soc. M. E. Proc.), New York, N. Y.; m; 4x7 in.; 50 cts.

Annales des Ponts et Chaussees (An. P. & C.), Paris, France; m.

Applied Science, Toronto, Ont.; m; 6x9 in.; 20 cts.

Architects and Builders Journal (Arch. & Bldrs. Jl.), Baltimore, Md.; m; 9x12 in.; 20 cts.

Architects and Builders Magazine (Arch. & Bldrs. Mag.), New York, N. Y.; m; 5x8 in.; 20 cts.

Architect and Engineer of California (Arch. & Engr.), San Francisco, Cal.; m; 5x7 in.; 15 cts.

Cassier's Magazine (Cas. Mag.), New York; m; 5x8 in.; 25 cts.

International Railway Congress Bulletin (Int. Ry. Cong. Bul.), Brussels; m; 50 cts.

California Journal of Technology (Cal. Jl. of Tech.), Berkeley, Cal.; m; 4x7 in.; 25 cts.

Canadian Architect (Can. Arch.), Toronto, Ont.; m; 7x19 in.; 20 cts.

Canadian Cement and Concrete Review (Can. Cem. & Conc. Rev.), Toronto, Ont.

Canadian Engineer (Can. Engr.), Toronto, Ont.; w; 7x11 in.; 10 cts.

Canadian Machinery and Manufacturing News (Can. Mach. & Mfg. News), Toronto, Ont.; m; 7x10 in.; 15 cts.

Canadian Mining Journal (Can. Min. Jl.), Toronto, Ont.; bi-w, 7x10 in., 20 cts.

Canadian Municipal Journal (Can. Mun. Jl.), Montreal, Que.; m; 6¾x10 in.; 10 cts.

Canadian Society of Civil Engineers Proceedings (Can Soc. C E. Proc.), Montreal; m; 4x7 in.; 50 cts.

Carpentry and Building (Carp. & Bldg.), New York, N. Y.; m; 11x8 in.; 10 cts.

Cassier's Magazine (Cas. Mag.), New York; m; 5x8 in.; 25 cts.

Cement, New York, N. Y.; bi-m; 5x8 in.; 25 cts.

Cement Age (Cem. Age), New York, N. Y.; m; 4x7 in.; 10 cts.

Cement and Engineering News (Cem. & Eng. News), Chicago, Ill., 7x10 in.; 25 cts.

Cement Era (Cem. Era), Chicago, Ill.; m; 7x10 in.; 10 cts.

Cement World (Cem. Wld.), Chicago, Ill.; m; 9x11 in.; 10 cts.

Chemical Engineer (Chem Engr.), Chicago, Ill.; m; 4x7 in.; 15 cts.

Clay Worker (Cl Wkr.), Indianapolis, Ind.; m; 7x10 in.; 20 cts.

Compressed Air (Comp. Air), New York, N. Y., m; 5x7 in.; 10 cts.

Concrete, Detroit, Mich.; m; 6x9 in.; 15 cts.

Concrete Age (Conc. Age), Atlanta, Ga.; m; 9x11 in.; 10 cts.

Concrete and Constructional Engineering (Conc. & Cons. Eng.), London, England; m; 5x7 in.; 25 cts.

Concrete Engineering (Conc Eng.), Cleveland, O.; m; 7x10 in.; 10 cts.

Contractor (Contr.), Chicago, Ill.; bi-w; 7x10 in., 20 cts.

Cornell Civil Engineer (Cor Civ Engr.), Ithaca, N Y; m; 4x7 in.; 25 cts.

Domestic Engineering (Dom. Engr.), Chicago, Ill., w; 6x9 in; 10 cts

Earth and Rock, Chicago, Ill; bi-w; 7x10 in; 10 cts.

Electrical Age (Elec. Age), New York, N. Y.; m; 7x10 in.; 10 cts.

Electrical Review (Elec Rev), New York, N Y.; 8x10 in; 10 cts

Electric Railway Journal (Elec. Ry. Jl.), New York, N Y; w, 7x10 in.; 10 cts.

Electrical World (Elec. Wld.), New York, N Y.; w, 7x10 in, 10 cts

Electric Traction Weekly (Elec. Trac. Wkly.), Cleveland, O.; w, 7x10 in.; 10 cts.

Engineer (Engr Lon.), London, England; w; 4x11 in.

Engineer (Engr.), Chicago, Ill.; bi-w; 7x10 in.; 20 cts.

Engineer (Eng.), London, England; w; 8x11 in.

Engineers' Club of Philadelphia Proceedings (Engr's Club Phila Proc.), Philadelphia; qr; 4x7 in., 25 cts.

Engineering-Contracting (Eng.-Contr.), Chicago, w, 7x10 in.; 10 cts

Engineering Digest (Eng. Dig.), New York; m; 5x8 in., 20 cts.

Engineering and Mining Journal (Eng & Min. Jl.), New York, w, 7x10 in.; 15 cts.

Engineering Magazine (Eng Mag.), New York, m, 5x7 in, 25 cts

Engineering News (Eng. News), New York, w, 8x11 in., 15 cts

Engineering Record (Eng. Rec.), New York; w, 8x11 in., 10 cts

Fire and Water Engineering (F & W Eng.), New York N Y 8x11 in.; 10 cts.

Le Genie Civil Paris, France; w.

Good Roads Magazine (Gd Rds. Mag.), New York, N Y, m, 7x10 in.; 10 cts.

Industrial Magazine (Ind. Mag.), Cleveland, O.; m; 4x7 in., 10 cts

Industrial World (Ind. Wld.), Pittsburg, Pa.; w; 7x10 in.; 10 cts

Inland Architect (In Arch.), Chicago, Ill.; m; 7x11 in; $1.

Insurance Engineering (Ins. Eng.), New York; m, 4x6 in, 25 cts.

Iron Age, New York, N. Y.; w; 7x11 in.; 15 cts.

Iron Trade Review (Iron T Rev.), Cleveland, O; w; 7x10 in, 15 cts.

Irrigation Age (Irr Age), Chicago, Ill.; m; 7x9 in.; 10 cts

Journal Association of Engineering Societies (Jl Asso Engr Soc.), Boston, Mass.; m; 4x7 in.; 30 cts.

Journal Franklin Institute (Jl. Frank Inst.), Philadelphia, Pa m. 4x7 in.; 50 cts.

Journal New England Waterworks Association (Jl. N E W W Assoc.), Boston, Mass.; q; 4x7 in.

Journal Western Society of Engineers (Jl W Soc. Engrs), Chicago, Ill.; bi-m; 4x7 in.; 50 cts.

Journal of Electricity, Power and Gas (Jl Elec. P & G), San Francisco, Cal.; w; 7x10 in.; 10 cts.

Journal of Worcester Polytechnic Institute (Jl. W P I.) m 4x7 in.; 20 cts.

Machinery, New York, N. Y.; m, 7x11 in.; 20 cts.

Marine Review (Marine Rev.), Cleveland, O.; w; 7x10 in, 15 cts

Mines and Minerals (Mi. & Mls.), Scranton, Pa; w; 7x9 in.; 20 cts

Mining and Scientific Press (Min. & Sci. P), San Francisco, Cal., w; 7x11 in.; 15 cts.

Mining Reporter (Min. Rep.), Denver, Colo.; w, 7x10 in., 15 cts.

Mining World (Min. Wld.), Chicago, Ill.; w; 7x10 in, 10 cts

Modern Machinery (Mod. Mchy.), Chicago, Ill; m, 7x10 in, 10 cts

Municipal Journal and Engineer (Mun Jl & Eng), New York N. Y.; w; 7x10 in.; 10 cts.

Municipal Engineering Magazine (Mun Eng Mag) Indianapolis, Ind.; m; 4x7 in., 25 cts

Ores and Metals (O. & M.), Denver, Colo.; bi-w, 6x10 in 10 cts

Pacific Building Engineer (Pac Bldg Engr), Seattle Wash, w, 9x11 in.; 15 cts.

Popular Mechanics (Pop. Mech), Chicago, Ill, m; 5x7 in, 10 cts

The Polytechnic (Poly.), Troy, N Y., m; 5x8 in, 15 cts

Power and Engineer (Pwr & Engr), New York m 7x10 in, 20 cts

Railway Age Gazette (R R Age Gaz.), New York, w, 8x11 in 15 cts.

Railway Master Mechanic (Ry. M. M.), Chicago; m, 7x10 in., 10 cts

Railway and Engineering Review (Ry & Eng. Rev), Chicago, Ill., w; 9x11 in, 10 cts.

Railway and Locomotive Engineering (Ry & Loco Eng) New York, N Y, m; 7x10 in., 20 cts.

Railway and Marine World (Ry & M Wld), Toronto Ont m 7x10 in, 15 cts.

Railway Engineering and Maintenance of Way (Ry Eng & M W), Chicago, Ill, m; 7x10 in, 10 cts

Roadmaster and Foreman (Rd & For), Chicago 7x10 in 10 cts

Rock Products (Rk Prod), Chicago Ill, bi-w, 9x11 in 10 cts

Rose Technic, Terre Haute, Ind, m 4x7 in 15 cts

School of Mines Quarterly (Sch. Min Quart) New York N Y qr, 4x7 in, 50 cts.

Schweizerische Bauzeitung Zurich w

Scientific American (Sci Am), New York, w, 9x14 in 10 cts

Scientific American Supplement (Sci Am Sup) New York N Y w, 9x11 in, 10 cts

Sibley Journal of Engineering (Sib Jl Eng) Ithaca, N Y m 4x7 in., 20 cts.

Stevens Institute Indicator (Stev Inst Ind), Hoboken N J m, 4x7 in.; 20 cts.

Street Railway Bulletin (St Ry Bul), Boston, m 6x10 in; 10 cts

Surveyor (Surveyor), London England, w, 6x11 in, 10 cts

Technology Quarterly (Tech Qr), Boston, qr, 4x6 in 35 cts

U S Department of Agriculture Bulletin (Dept Agr Bul.) Washington, D C, 4x7 in

U S Geological Survey Bulletin (Geo Surv Bul) Washington, D C, 4x7 in.

Waterproofing and Fireproofing (W P & F P), Detroit Mich, m, 7x10 in.; 10 cts.

Zeitschrift d Oest. Ing. u Arch. Ver Vienna, w

Zeitschrift d. Ver Deutscher Ing., Berlin, w

ROADS AND STREETS.

The Cost of Road Construction in the United States.—By Maurice O. Eldridge. Gd. Rds. Mag., December, 1908. 5½ pp.

A report submitted at the First International Road Congress. The report contains several tables showing the cost of experimental roads constructed by the U. S. Office of Public Roads, the cost of sand-clay roads, and roads constructed by various state highway departments.

Care and Preservation of Street Trees.—By Albert D. Taylor. Gd. Rds. Mag., December. 1908. 5 pp.

The matter is taken from a bulletin issued by the College of Agriculture, Cornell University. It treats of the damage to street trees by escaping gas, electricity, regrading work, etc.

How Imperial Pavement is Laid.—By W. B. Spencer. Gd. Rds. Mag., December, 1908.

An address before the Good Roads Automobile Convention at Atlantic City, N. J.

The New Era of Road Construction.—By James E. Owen. Gd. Rds. Mag., December, 1908. 2 pp.

An address before the Good Roads Automobile Convention at Atlantic City, N. J. It treats of the growth of the general principles of road construction and the adaptation of these principles. Suggestions for the better adaptation of the highway to present conditions are also given.

Preservation of Park Roads.—By Col. Chas. S. Brownell. Gd. Rds. Mag., December, 1908. 2 pp.

Describes the preservation of park roads in the advent of the motor car.

Cost of Constructing a 25-ft. Cement Sidewalk and Curbing in Michigan Ave., Chicago, Ill.—Eng.-Contr., Dec. 9, 1908. 2/3 p.

Gives cost of constructing a 25-ft. cement sidewalk. Cost of treating surface with acid solution is also included.

The Selection of Dust Preventives.—By Prevost Hubbard. Eng.-Contr., Dec. 30. 1908. 2 pp. Gd. Rds. Mag., December, 1908. 5 pp.

Describes selection of material for treating country roads, suburban roads and park roads. The matter is taken from a bulletin of the U. S. Office of Public Roads.

Dust Prevention in the Parks of Boston, Mass.—By John A. Pettigrew. Eng.-Contr., Dec. 30, 1908. 2/3 p.

Describes methods and gives some costs of dust prevention in the parks of Boston, Mass.

General Figures on the Cost of Road Construction in Various Parts of the United States.—Eng.-Contr., Dec. 23, 1908. 1 2/3 pp.

General cost figures in the construction of object lesson roads, sand-clay roads, macadam roads in Massachusetts, road work in Connecticut, road work in New Jersey, gravel and macadam roads in Indiana and oiled roads in California.

Asphaltic Concrete Pavement Surfaces.—Eng.-Contr., Dec. 23, 1908. 1/3 p.

Description of composition of asphaltic concrete surface on Thames Embankment at London, England.

Law Suit for Use of Oil and Water on Roadways Decided in Favor of the Public.—Eng.-Contr., Dec. 23, 1908. ⅔ p.

Decision in U. S. Circuit Court at Chicago on use of oil and water in laying dust in streets and roadways.

Asphalt Testing - Ductility.—By Henry Tipper. Mun. Jl. & Eng., Dec. 9, 1908 2 pp.

A discussion of the value of the ductility test of asphaltic cement used for paving purposes.

Testing Asphalt.—By Harry Tipper. Mun Jl. & Eng., Dec. 2, 1908. 1½ pp.

Calls attention to alleged serious deficiencies in the present methods of testing asphaltic substances intended for paving.

The Akonia Process of Dust Prevention.—By Eric Daniel de Liebhaber. Surveyor, Nov. 20, 1908. 1½ pp.

A description of the Akonia process for preventing dust. The process is based on the chemical treatment of the road surface with certain substances of a hygroscopic nature.

Examination of Tars for Use on Roads.—By Clayton Beadle and Henry P. Stevens. Surveyor, Dec. 4, 1908. 2½ pp.

Gives an outline of the experimental work and a description of the tests and results obtained.

Method of Constructing a Road Through Swampy Land.—Eng.-Contr., Dec. 2, 1908. 1/3 p.

Describes method of constructing macadam road ⅞ mile long through bottom land and swamp.

Methods and Costs of Constructing 990 Lin. Ft. of 15-ft. Cement Walk at Nelson, B. C.—Eng.-Contr., Dec. 2, 1908. ⅔ p.

Describes the construction and gives cost of constructing the walks.

An Asphaltic Macadam Highway at Rye, N. Y., Built by the Petrolithic Process.—Eng.-Contr., Dec. 2, 1908. 1 p.

Describes the method of rebuilding a highway at Rye, N. Y., which had been badly cut up by motor traffic. The petrolithic process was employed in the work.

The Mineral Rubber Pavement.—By Linn White. Mun. Eng. Mag., December, 1908. 2 pp.

Description of the mineral rubber pavement, taken from a paper read before the American Society of Municipal Improvements.

The Blome Concrete Pavement.—By Harry S. Dewey. Mun. Eng. Mag., December, 1908. 2½ pp.

Describes the construction of the Blome system of concrete pavements and gives specifications for the Blome system of granitoid concrete, block pavement. The matter is taken from a paper read before the American Society of Municipal Improvements

Pavement Assessments and Collections.—By E. R. Schreiter. Jr. Mun. Eng. Mag., December, 1908. 2 pp.

Describes the method employed at Detroit, Mich., for the above. The matter is taken from a paper read before the League of American Municipalities.

The Value of the Carbene Requirement in Asphalt Specifications.—By L. Kirschbaum. Mun. Eng. Mag., December, 1908. 3½ pp.

Describes the investigations made in connection with the preparation of asphalt specifications for the city of Chicago to determine the value of the carbene test, which is used for the purpose of detecting those asphalts which have been injured by severe heat treatment in the process of refining or production.

Bituminous Macadam Road Construction in Rhode Island and Specifications for the Work.—Eng.-Contr., Dec. 9, 1908. 2 pp.

Describes the methods employed in the construction of a bituminous macadam road and gives specifications under which the work was done. Some figures of cost are also given. The work was done in 1908 under the supervision of the State Board of Public Roads.

Road Construction and Maintenance in Gloucester County, England.—By Robert Phillips. Eng.-Contr., Dec. 16, 1908. 2 pp.

Describes the various kinds of roads in Gloucester county, and gives the method of construction and maintenance.

Old and New Methods of Asphalt Paving.—By Guy B. Grant. Mun. Eng. Mag., December, 1908. 2½ pp.

Describes the construction of an asphalt pavement in 1882 at Omaha, Neb., and compares the present method of paving with the methods employed 26 years ago.

The Blome Method of Constructing Concrete Pavements.—Eng.-Contr., Dec. 16, 1908. ⅔ pp.

Description, including specifications of the Blome system of granitoid blocked pavement.

SEWERS.

Cost of Five-Foot Concrete Sewer.—Cem. Era., December, 1908, 1¾ pp.

Describes briefly method of constructing sewer with cost figures for trenching by steam shovel, sheeting and concrete work. Figures show very low costs and are partial only.

Observations of Methods, Cost and Results of Sewage Purification Abroad. By H. W. Clark. Jl. Assoc. Engr. Soc., November, 1908, 50 pp.

This is a valuable paper and discussion to sanitary engineers. The author describes the works visited and in particular gives records of results and costs of treatment that are of high value and interest. Both British and Continental European practice are represented by the plants visited.

Method of Building a Storm Water Sewer in New York With Some Costs. Eng.-Contr., Dec. 2, 1908, 3¼ pp.

Describes the use of trench machines and steam shovels for trenching and gives some costs of the steam shovel work. The method of blasting and excavating rock is also described and the use of a special pile driver for driving sheeting is explained. There are also data on the use of metal forms for the arch.

Intake Tunnel and Crib of Laurence Ave. Pumping Station, Chicago. Eng.-Rec., Dec. 19, 1908. 2⅓ pp.

A description is given of this intake tunnel and crib, showing the details of construction and the methods of carrying on the work. A tunnel over 1,400 ft. long was driven under Lake Michigan.

Some Details of the Design and Construction of the Baltimore Sewerage System. Eng. Rec., Dec. 19, 1908. 3 pp.

Many of the details of the work on this sewerage system are described and illustrated and it is shown how difficulties that were encountered were overcome. Some of the problems to be solved were quite interesting.

Lawrence Experiments Regarding the Distribution of Sewerage Over Sprinkling Filters. Eng. Rec., Dec. 26, 1908. 3⅔ pp.

Considers the results so far obtained of the Massachusetts Board of Health's experiments as to the different methods of distributing sewage over sprinkling filters. Many varieties of sprinklers have been tried.

Methods of Making Tight Joints in Pipe Sewers. By B. E. Briggs. Eng.-Contr., Dec. 9, 1908. 1⅓ pp.

Notes lax practice in securing tight joints in pipe sewers and cites examples, discusses advantages of tight joints and difficulties of obtaining them under various conditions, describes joint constructions used at Erie, Pa. Special gasket joints and long lengths of pipe are used. An article of interest to city engineers.

Estimating the Cost of Manholes from a Diagram. By John Wilson. Eng.-Contr., Dec. 9, 1908. ⅓ p.

Gives diagram and explains method of using it. Having given the depth of manhole, then the number of brick, amounts of sand, cement and mortar, the cost of labor and the total cost of the manhole plus 15 per cent profit can be read from the diagram.

Bronx Valley Sewer Construction.—Mun. Jl. & Eng., Dec. 30, 1908. 4½ pp.

Describes the construction of the Bronx Valley sewer—an intercepting sanitary and outlet sewer being built through White Plains, Greensburg, Scarsdale, East Chester, Mt. Vernon and Yonkers, N. Y.

Sewer Construction in Chicago. Mun Jl. & Eng Dec 2, 1908. 5 pp.

A general descriptive article of the construction of the 95th St. sewer system in Chicago. The sewers were of concrete

The Hampton Doctrine in Relation to Sewage Purification. By Dr. A. Lubbert. Surveyor, Dec. 4 and 11, 1908. 5 pp.

A criticism of the theory that the Hampton doctrine has been demonstrated to be a rational interpretation of practical sewage disposal operations. The matter is translated from a report to the Hamburg State Hygienic Institute.

Tight Joints in Pipe Sewers.—By B. E. Briggs. Mun. Eng. Mag., December 1908. 2½ pp.

A paper read before the American Society of Municipal Improvements, in which it gives various methods of securing tight joints in pipe sewers.

WATER-WORKS AND HYDRAULICS

Co-efficients of Discharge Through Sluice Gates and Over Wires. By H. F. Labelle. Eng. Rec., Dec. 26, 1908. 1½ pp.

A discussion of the measuring of water flowing through orifices, showing its importance in irrigation work. The various formulas for this purpose are considered and commented upon. Some computed discharges are compared with actual gaging.

A Low Head Hydro-Electric Development at Berrien Springs, Michigan. Eng. Rec., Dec. 26, 1908. 3½ pp.

A description is given of the design and construction of this concrete dam built for power purposes.

Construction of the Croton Falls Reservoir. Eng. Rec., Dec. 12, 1908. 4 pp.

The contractor's method of carrying on this work is described in detail, and much of the plant used is described and illustrated.

Construction of the Little River Water Supply for Springfield, Mass. Eng. Rec., Dec. 12, 1908. 3½ pp.

A description of the work and of the method used by the contractors. The water is taken from a river and filtered.

Purification of Ground Waters Containing Iron and Manganese. By R. S. Weston. Proc. Am. S. of C. E., Dec., 1908. 70 pp.

Shows the importance of ground water supply, and its advantages. Considers the character of ground waters, the deterioration of the supply and other features. Shows both American and European practice of purifying ground waters containing iron and manganese.

Problems in Designing the Kern River No. 1 Hydro-Electric Power Plant. By F. C. Finkle, Eng. News, Dec. 24, 1908. 9½ pp.

A valuable article on hydraulic power plant design. A general description of the plant is given, then the author explains the methods of designing the intake, the gravity conduit, the waste flume, the force main and the impulse turbines. Diagrams and formulas used are stated and methods of computation explained. The article is copiously illustrated.

Methods and Some Costs of Driving Stove Pipe Wells on Long Island. By Walter E. Spear Engr.-Contr., Dec. 2, 1908 1¼ pp.

The plant for well driving is described and improvements on former methods of operation are explained The method of driving is then described in detail. General figures on cost of driving per foot of well are given

Methods of Making Rubber Pipe Joints With Some Costs. By R. S. Weston. Eng.-Contr., Dec. 16, 1908. 1⅓ pp.

Describes construction of rubber joint, gives sizes of pipe and comparative costs of lead and rubber joints for various sizes.

Cataract Dam, Sydney, New South Wales. Eng. News, Dec. 3, 1908. 1 p.

Shows view of completed dam and of character of masonry and gives principal dimensions, quantities of materials and some remarks on construction. This dam is

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mainly of cyclopean masonry, 811 ft. long and 157 ft. high above river bed.

Experimental Hydraulic Dredge Fill Dams at Gatun Made for the Isthmian Canal Commission. By C. M. Saville, Eng. News, Dec. 24, 1908. 5½ pp.

To obtain data on water tightness of Gatun dam an experimental section of dam one-twelfth the size of the Gatun dam was constructed and tested. The report of these tests is abstracted in this article.

Water Works Valuation and Fair Rates in the Light of the Maine Supreme Court Decision in the Waterville and Brunswick Cases. By Leonard Metcalf. Eng.-Contr., Dec. 16 and 23, 1908, and Jan. 6, 1909. 13 pp.

Points out instructions for water works valuation and rate determination contained in decisions mentioned and discusses their application. A notably valuable paper for cost analysis engineers.

Newton's Water Supply System.—By A. W. King. Mun. Jl. & Eng., Dec. 23, 1908. 4½ pp.

Describes the water supply system of Newton, Mass. Supply is obtained through pipe wells. Methods of constructing extension of the system is described; as is methods of handling ground water.

* **Slip of Pumping Engines.**—Mun. Jl. & Eng., Dec. 16, 1908. 4 pp.

Discusses importance of considering slip in water works calculations and gives the results of tests in 30 cities showing slip of pump. Various methods of measuring slip are described.

Rubber Water Pipe Joints. Mun. Jl. & Eng., Dec. 2, 1908. 1½ pp.

Describes the use of rubber rings without lead or other substance for making tight water pipe joints. Comparative costs of lead and rubber pipe joints are given. The matter is taken from a paper by Robert Spurr Weston, read before the New England Waterworks Association.

DRAINAGE AND IRRIGATION.

Seepage and Loss of Water From Lined and Unlined Irrigation Ditches With Some Costs. Engr.-Contr., Dec. 2, 1908. 3¾ pp.

Report of series of tests made on the relative efficiency of canal linings in resisting seepage. Twelve ditches were tested, some unlined and others lined with concrete, cement mortar, cement lime concrete, puddle and road oils. Construction of linings is described and results of tests are given in tabular form.

Cost of Pumping from Wells for the Irrigation of Rice for Eighteen Pumping Plants in Louisiana and Arkansas. Eng.-Contr., Dec. 16, 1908. 1¼ pp.

The tests were made to show the cost of water supplied and in general the efficiency of the machinery used. Table showing results gives for each plant the lift, first cost, area irrigated and the first cost, fixed charges, fuel cost, attendance cost and total cost per acre irrigated.

Methods and Costs of Lining Ditches and Canals. Eng.-Contr., Dec. 30, 1908. 5 pp.

Describes six methods of lining irrigation canals giving specific examples with results and costs of work. A valuable article for irrigation engineers as methods and costs are very fully presented.

RIVERS, HARBORS AND CANALS.

Successful Low Timber Dam for Broad Sandy River Channels. By O. E. Parker. Eng. Rec., Dec. 5, 1908. 1 p.

A description and plan is given of a dam of this character that was built on the Arkansas River. The methods of doing the work is also described.

Present Condition of Work on the Panama Canal. Eng. Rec., Dec. 5, 1908. 8 pp.

The general situation as to plans for future work and also of the work that has been done is described in this article. The data from which it is written is taken from the recent annual report, the Canal Record and other sources.

Utility of Waterways as a Factor in Transportation. By J. A. Ockerson. Eng. Rec., Dec. 19, 1908. 2⅛ pp.

An address before the River and Harbor Convention being a plea for inland waterways giving statistics showing the benefit from such waterways in Europe.

Structural Steel Ore Dock at Two Harbors, Minn. Eng. Rec., Dec. 5, 1908. 2½ pp.

A description is given of this 50,000-ton steel ore dock, and of the methods of erecting the structure. The dock is owned by the Duluth & Iron Range R. R.

Improvement of the Detroit River for Navigation. Eng. News, Dec. 17, 1908. 3 pp.

Describes the New Livingstone Channel work and reviews work done on the Amhurstburg Channel. Drill boat for rock excavation under water is illustrated and described. Some 7,500 ft. of channel is rock excavation within cofferdams and cofferdam construction, air lift pumping plant and cableway excavating plant are described

Design of Canal Diversion Wiers on a Sand Foundation. By W. G. Bligh. Applied Science, November, 1908. 11 pp.

Describes the means to be adopted to insure the safety of wiers, which are not only exposed to undermining by their foundation being washed out by subsoil perculation, but are also subject to scouring action of the powerful current of a river in flood, which completely submerges the whole work. A paper of interest to hydraulic engineers.

Analysis Showing that the Panama Canal is Certain to Cost at Least $210,000,000 or 50 per cent More Than Originally Estimated. Engr.-Contr., Dec. 2, 16 and 30, 1908. 1¾ pp.

Summarizes figures of expenditures and work done from reports of the Isthmian Canal Commission and demonstrates that, if corresponding construction costs are assumed for work remaining to be done, the canal will cost some 50 per cent more than it was estimated to cost. Demonstrates extravagant costs of work as it is now being carried on.

Extracts from the Annual Report of the Isthmian Canal Commission. Eng. News, Dec. 3, 1908. 4 pp; Earth & Rock, Dec. 1, 1908, 2¾ pp.; Eng. Rec., Dec. 5, 1908, 8 pp.

Reprints of portions of the main report of the Commission for the year ending June 30, 1908, giving a general outline of the work done and a summary of the year's expenditures and receipts.

Continuous Wooven Mattress Rivetment Compared to the David Neale System. By W. R. DeWitt and Chas. H. Miller. Eng. News, Dec. 10, 1908. 2¼ pp.

A criticism by Mr. DeWitt of the David Neal system of bank protection and an answer thereto by Mr. Miller.

Silt in the Proposed Reservoirs of the Ohio Basin. By Herman Stabler. Eng. News, Dec. 10, 1908. 2 pp.

Discusses the question of the objections, due to silting up of reservoirs, to the reservoir system of regulating Ohio River floods. Gives estimates showing that it would take some 500 years accumulation of silt to reduce capacity of reservoirs by 10 per cent. Probably accuracy of estimates discussed.

Permanent Improvement of the Ohio River.—By Capt. P. S. Bond. Eng Rec., Dec. 26, 1908 and Jan. 2, 1909. 8 pp.

This article describes the improvements being made by the National Government in the Ohio river. Description is given of the various locks and dams that are being built and much of work is described in detail, being illustrated with photographs and drawings.

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RAILWAYS.

Cost of Light and Heavy Cars in Railway Operation. Elec. Ry. Jl., Dec. 5, 1908. ½ p.

Gives estimates comparing investment and operating costs of semi-convertible cars vs. a mixed equipment for city and suburban service.

Brake Shoe Methods and Costs on the Metropolitan West Side Elevated Railway, Chicago. Elec. Ry. Jl., Dec. 5, 1908. 1 p.

Gives costs of brake shoes for year ending Nov 1 1908, in detail, and describes methods and results of new plan to reduce brake shoe wear and expenses.

Track Reconstruction in New York. Elec. Ry. Jl., Dec. 26, 1908. 2 pp.

Shows drawings of standard track and trolley conduit construction using 9-in. rail for track reconstruction for the Metropolitan Street Ry. Co., in New York City. The work is described in some detail.

Rail and Water Terminal at Bristol, England; Great Western Ry. Eng. News, Dec. 10, 1908. 2 pp.

A general description of the lay-out, equipment and construction of this new terminal with some interesting views and plans of a reinforced concrete freight station.

Steel Tie and Concrete Tie Construction. By C. H. Clark. Can. Engr., Dec. 4, 1908. 1¾ pp.

This paper relates chiefly to steel tie construction for railway and street railway track. It describes early forms of steel ties and in particular the Carnegie steel tie, points out the advantages of steel ties and compares the cost of steel and wood ties.

Building and Maintaining Railroad Crossings. By W. C. Sparks. Eng.-Contr., Dec. 30, 1908, 1⅓ pp.; Can. Engr., Dec. 4, 1908, 1¼ pp.

Discusses present practice in crossing construction and suggests a design and construction for a crossing founded on crushed stone on a concrete foundation. The maintenance of crossings is discussed.

Cost of Street Railway Track. Eng. Rec., Dec. 19, 1908.

The cost of track construction of three different lines of the Utica & Mohawk Valley Ry. is given, showing each item of cost both for materials and labor. The wages paid are not listed

Railway Capital and Values. By W. H. Williams. Ry. & Eng. Rev., Dec. 26, 1908. 2½ pp.

The subject is discussed from a general standpoint and the methods of valuation used in Michigan are described. The headings commented upon are physical properties; non-physical properties; taxation; rates and capitalization.

Methods and Cost of Handling Locomotive Coal and Ashes. By C. F. Whitton. Eng.-Contr., Dec 2 1908 3¾ pp.

Describes various types of plants commonly used for coal and ash handling, discusses their capacity characteristics, methods of operation and gives examples of cost of operation A valuable paper for railway engineers.

Reinforcing Corroded Trolley Poles. Comp Air, Dec., 1908. ¾ p.

Describes a method of filling a hollow iron pole with concrete and placing in it some reinforcing steel rods. A special machine is used for the purpose, which does the job both quickly and cheaply

Steel Rails in Canada. By F. P. Gutelius. Can. Ry. Club. December, 1908 18 pp

A paper giving the writer's experience with steel rails on the Canadian Pacific Ry. Gives rules of that railroad for laying and caring for rails also specifications for 85-lb open hearth and Bessemer rails

BRIDGES, BUILDINGS AND FOUNDATIONS.

Special Structural Steel Work in the La Salle Hotel, Chicago. Eng News, Dec. 3, 1908. 3⅓ pp.

General description of steel work of a 21-story building with drawings of special truss work, roof arches and column sections.

Temporary Bridge Across the Cornwall Canal and Permanent Repairs to Canal Break. Eng News, Dec 17, 1908. 2¾ pp.

Describes the construction of the temporary bridge to cross the canal in place of the bridge washed out during the break on June 23, 1908 A general description of the permanent repairs to the break and of the permanent drawbridge follows.

Discussions Before the Technical League on the Blackwells Island Bridge. Eng.-Contr., Dec. 9 and 23, 1908. -¾ pp.

Loadings assumed and methods of computation are commented on and criticized. statement that there was "not a single stress One of the discussions makes the startling correctly calculated."

Construction of the Manhattan Bridge Cables.—Eng. Rec., Dec. 5, 1908. 4 pp.

A description is given of the fabricating and erecting of the cables for this new suspension bridge; well illustrated, the drawings and photographs adding to the value of the text.

Test of Suspender Ropes for the Manhattan Bridge, New York.—Eng. Rec., Dec 19, 1908. ⅔ p.

Description is given of the suspender ropes, and also of the test made upon them.

Proposed Structural Improvements for the Elevated Terminal Loop at Chicago.—Eng. News, Dec. 17, 1908. 2 pp.

Abstracts report of Charles Mohler, Engineer Loop Protective Association, on method of improving traffic capacity and reducing noise on the elevated loop terminal in Chicago. Two suggested constructions of track to reduce noise are illustrated.

Weights and Costs of Eight Lift Bridges.—Eng.-Contr., Dec. -, 1908. 1 p.

The bridges tested are of various types of bascules, and the data given covers weights, dimensions and general costs.

Method and Cost of Removing a Suspension Bridge.—Eng.-Contr., Dec. 16, 1908. ½ p.

Describes the bridge, gives original cost, quantities involved and cost of removing cable and masonry work.

Cement Tile.—By E. S. Hanson. Cem. Era., December, 1908. 2 pp.

Describes briefly cement tile factory at Estherville, Ia., and gives figures of cost of manufacture.

Waterproofing Cement at the Mill.—By Mr. B Potter. Cem Era December 1908 2 pp.

The paper states the requirements of a waterproofing process, and then gives results of tests made.

Reinforced Steel Construction; Sterling & Welch Co. Building.—Conc Eng December 1908 6⅔ pp

The construction described is a combination of self-supporting steel frame and door rods embedded in concrete This type of construction is described and its advantages stated, details of construction are shown and some of the contractor's methods described with drawings of forms mixing plant lay-out concrete cars, etc

CONCRETE AND REINFORCED CONCRETE.

Time of Removal of Centers in Concrete Sewer Construction.—By Albert C Lehman Eng. Rec., Dec 12, 1908 ½ p.

Comments are made on the length of time to leave in centers on sewer work and some records are given of actual time before which the centers were removed

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Designing Methods Reinforced Concrete Construction; Reservoirs.—Bulletin Corrugated Bar Co., St. Louis, Mo., December, 1908. 23 pp.

This is bulletin No. 6, of Vol. 1, issued by this company on the above subject, this pamphlet being devoted to reservoirs. Gives specifications for materials, detail design of rectangular reservoirs, the stability against earth pressure, stability against water pressure, dividing walls and reinforcement required.

Concrete Sewage Tank Reinforced Against External Pressure.—Eng. Rec., Dec. 19, 1908, 1 p.

A description is given of a concrete tank built for sewage, in which the sides were designed to withstand external pressures when the tank is empty. Plans showing the tank are given.

Reinforced Concrete Freezing Tanks.—By W. M. Torrence. Eng. News, Dec. 10, 1908. ¾ p.

Describes with general plans and details the design and construction of a rectangular reinforced concrete freezing tank. Forms of insulation are discussed in some detail.

Reinforced Concrete Pipe with Reinforced Joint.—Eng. News, Dec. 10, 1908. ¾ p.

Describes construction of pipe and of joint in detail and illustrates metal mold for casting pipe. Tests of pipe are also described and results given.

Effect of Calcium Aluminate on Various Lime and Natural Cement Mortars.—Eng. News, Dec. 10, 1908. ¾ p.

Gives results of tensile tests made to determine the effect of the addition of calcium aluminate to lime and natural cement mortar. The tests indicated an improvement of the mortars due to the addition.

Lynhurst Bridge.—By A. Gillies, Can. Engr., Dec. 4, 1908. 2¼ pp.

General description with drawings of a reinforced concrete arch highway bridge of 116 ft. clear span. Wages, prices of materials and contract prices are given.

Standard Designs for Reinforced Concrete Bridges of the Illinois Highway Commission with Some Details of Cost.—Eng.-Contr., Dec. 2, 1908. 1⅔ pp.

Gives drawings of standard plans and describes character of construction. A table shows for 18 bridges built after these designs, the dimensions, quantities and costs per lineal foot.

Methods and Cost of Constructing Three Wooden Highway Bridges with Concrete Abutments.—By Charles McKeroher. Eng.-Contr., Dec. 9, 1908. ¾ p.

The bridges were of 16.4 ft. span, built of native (Cuban) woods. Itemized costs are given of wood superstructure and also of concrete abutments.

Tests Showing Loss by Solution of Cement in Concrete Drain Tile.—By A. O. Anderson. Eng.-Contr., Dec. 9, 1908. ¾ p.

Describes a series of tests made in concrete drain tile to determine whether cement is dissolved from such tile by soaking. Results of tests are stated in tabular form.

Tests of Reinforced Concrete Columns.—Eng. News, Dec. 3, 1908. ½ p.

Gives in tabular form results of tests of 17 reinforced and 2 plain concrete columns 9 ins. square and 9½ ft. and (for the plain concrete) 5 ft. long. Results were very erratic and give few data of value.

Testing of Portland Cement for Use in the Tropics.—Eng. News, Dec. 3, 1908; 3½ pp.; Eng.-Contr., Dec. 16, 1908, 1⅔ pp.; Eng. Rec., Dec. 5, 1908, 1½ pp.

Reprint of parts of a report on this subject made to the Bureau of Science at Manila, P. I. Modern cement specifications are discussed and criticised and a very interesting summary given of climatic influences on Portland cement. An article of value to engineers in tropical countries.

Now Ready

CONCRETE CONSTRUCTION

METHODS AND COST

By

Halbert P. Gillette
M. Am. Soc. C. E., M. Inst M. E.,
Managing Editor, Engineering-Contracting
and
Charles S. Hill, C. E.,
Associate Editor, Engineering-Contracting.

THIS book handles the subject of concrete construction entirely from the view-point of the ***builder*** of concrete structures. The testing of cement, the physical properties of cements and concrete, and the design of concrete structures are not considered. The aim of the authors has been to eliminate all matter not germane to the constructing end of their subject. By doing this it has been possible to crowd a vast amount of detailed information on methods and cost of concrete construction into a volume of moderate size. The book is a treatise on the ***methods and cost*** of building in ***concrete.***

WHILE concrete design is not considered, no designer of concrete can be a really good designer without having a profound knowledge of costs and of practical methods of construction. This book will be of interest therefore to every engineer and architect who is engaged in designing concrete structures. It should be of particular assistance, however, to the contractor or engineer engaged in the actual work of making and placing concrete.

THE methods given are practical methods and they are so given that the practical man can use them. The costs given are actual costs, itemized, analyzed and reduced to units. Costs of material, costs of transporting, costs of mixing, costs of placing, costs of tamping, costs of finishing, costs of forms, costs of bending and placing reinforcement, costs of waterproofing, costs of superintendence, costs of plant, interest charges, depreciation charges are all given, and to make these costs useful, the conditions and the methods of doing the work are stated in each case.

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Shop-Made Reinforced Piles.—By L. J. Mensch Eng News, Dec 3 1908. ¾ p.

Describes method of molding and driving reinforced concrete piles for a building foundation Drawings of forms and of cushion cap used in driving are shown Mention is also made of hollow concrete piles molded by the author for San Francisco harbor work.

Specifications for Test Specimens of Concrete to be Immersed in Sea Water by the United States Navy Department.—Eng.-Contr., Dec. 30, 1908, 1¼ pp., Eng. News Dec 24, 1908, ½ p.

The object of these tests is to determine what the action of sea water is upon concrete, both as regards climatic condition and chemical action. The article gives the specifications drawn to govern the preparation of the test specimens, their location and their observance.

Manufacture of Portland Cement from Materials High in Magnesia.—By R K. Meade. Cem. Age, December 1908 3 pp.

Reviews briefly the work of Dykerhoff and of Professors Campbell and White on this subject, and describes and gives results of tests made by the author

Effect of Magnesia in Portland Cement.—By Rudolph Dykerhoff. Cem. Age, December, 1908. 4 pp.

Summarizes results of investigations made to determine what dangers occur from the use of Portland cement high in magnesia. Paper concludes that magnesia content should not exceed 4 per cent.

Manufacture, Erection and Demolition of Forms for Concrete Work.—By F. W. Wilson. Eng. News, Dec. 17, 1908. 1⅓ pp.

Argues the economy of having form work done at mills from completely worked out designs; also outlines rules to be followed in designing so that forms can be readily removed.

De Muralt System of Reinforced Concrete Shore Protection.—Eng. News, Dec. 17, 1908. 1 p.

Describes briefly this system of reinforced concrete revetment or slope paving which has been used in Holland; shows forms for constructing revetment and gives some details of methods.

Tests of the Effect of Electric Currents on Concrete.—By U. J. Nicholas, Eng. News, Dec. 24, 1908. 2⅓ pp.

Describes series of tests to determine (1) the insulating properties of concrete, and (2) the effect of the current on the concrete and its steel reinforcement. The tests indicated broadly that electrolytic corrosion of the steel occurs at the anode and that concrete in brine will crack when carrying an electric current to and from embedded steel.

Collapsible Forms for Concrete Culverts.—Eng.-Contr., Dec. 16, 1908. ⅓ p.

Shows drawings for a form composed of staves strung together on wires like a rolling shutter and wrapped around circular heads to make the "bore."

Tests of Adhesion Between Concrete and Steel.—Eng.-Contr., Dec. 16, 1908. ¼ p.

Tests were made on ¾ and ⅞-in. bars embedded 9 ins. in a 8x8x12-in concrete block. Some of the bars were clean and others rusted, oiled or painted. Results are given in tabular form and show painting and oiling practically to destroy adhesion.

Some Details of Form Construction for the Philadelphia Subway.—Eng.-Contr., Dec 30, 1908. ¾ p.

Describes machine for bending reinforcement and general rules for designing forms.

Construction Details of Reinforced Concrete Work.—By De Forest H. Dixon. Eng.-Contr., Dec. 23, 1908. 3¼ pp.

Points out the requirements for safe and economical reinforced concrete work of design, inspection of materials, form work, placing concrete finishing work, etc A good article of general advisory character.

Cost of Constructing Concrete Piers for a Highway Bridge.—By H A Young Eng.-Contr ⅔ p.

Describes method of constructing two piers with wing walls containing about 130 cu yds of concrete and requiring 413 cu yds. of excavation Itemized cost of materials and labor are given for both excavation and concrete work

Changes in the German Standard Cement Specifications.—Eng Rec Dec 26, 1908 ⅔ p

Tells the important part in the cement industry these specifications have taken. The recent changes made are listed under different headings. From a report of a committee of the Association American Cement Manufacturers.

EARTH AND ROCK EXCAVATION.

Improved Ladder Type of Excavator for Trench Digging.—Earth and Rock Dec. 17, 1908. 2⅓ pp.

Describes construction and operation of a ladder type of trench excavator, points out its economy over hand labor and gives records and some costs of work.

Methods and Costs of Driving the Hot Lime Lateral of the New House Tunnel.—By Henry M. Adkinson. Eng.-Contr, Dec. 2 1908. 2 pp.

Showing the methods used in driving a 5x7½-ft. adit, giving monthly records of driving. Diagram of the spacing of the holes for blasting is shown and the cost of the work per lin. ft. of tunnel and per cu. yd. is given.

Cost of a 4,000 Lbs. Blast.—Eng.-Contr., Dec. 2, 1908. ¼ p.

A short article giving the cost in detail of blasting for steam shovel excavation. Gives the amount of power used for cu. yd. of material excavated.

Cost of Operating and Maintaining an Electric Air Drill and Some Suggestions as to the Advantages of this Type of Drill for Trench Work.—Eng.-Contr., Dec. 9, 1909. ½ p.

Gives the cost of drilling for a month's work and the cost of maintaining the drill for 10 months. Comments are also made on the adaptability of the drill to trench work.

Some Comments on Blasting in the Culebra Cut, and the Proposed Close Spacing of Drill Holes to Prevent Misfires.—Eng.-Contr., Dec. 9, 1908. ¾ p.

Shows in the article the increased cost of close spacing of blast holes, and that this close spacing will not prevent misfires, but will only add to their chance.

Records of Driving Rock Tunnels and Some Comments on the High Cost of the Elizabeth Tunnel.—Eng.-Contr., Dec 9 1908 1 p.

Records are given of the best records made in tunnel driving in Europe and also in the United States, thus giving the best records in the world A table of cost is given of some well known American tunnels, showing the cost of driving the Elizabeth tunnel to be excessive.

Compressed Air at High Altitudes.—By S B. Redfield. Comp. Air, December, 1908 6½ pp.

The author shows why more air is required, and gives a simple method for calculating the power needed for compressing The article is illustrated with diagrams.

Some Drilling Records; the Daily Cost of Maintaining Electric Air Drills, and the Advantages of this Drill in "Sticky" Rock.—Eng.-Contr., Dec. 23, 1908 ½ p.

In this article the record of two drills is given, as to the amount of work done by them and also the cost of keeping them in repair, showing the parts subject to the most wear

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Cost of Cold Springs Reservoir, Umatilla Irrigation Project, U. S. Reclamation Service.—Eng.-Contr., Dec. 16, 1908. ⅔ p.

The cost of the excavation work done on this project is given in a table showing the various details of the cost.

Methods and Costs of Driving a Tunnel with Hand Steel Holes.—Eng.-Contr., Dec. 16, 1908. ½ p.

The method of placing holes, blasting and renicking in a 6x7 mining tunnel is given in detail, showing the cost per cu. yd. and also per lin. ft. of tunnel.

Methods and Cost of Subaqueous Rock Excavation Using a Lobnitz Rock Breaker at Blyth Harbor, England.—Eng.-Contr., Dec. 23, 1908. 2½ pp.

The methods of operation are described at some length, and the cost of doing the work in some detail is given. Extracted from a paper before the Institute of Civil Engineers.

Handling Crushed Rock on San Francisco Bay.—By F. K. Blue, Eng. & Min. Jl., Dec. 12, 1908. 2⅓ pp.

Describes the method of quarrying, crushing and handling rock by the San Patlo Quarry Co., at San Francisco. Belt conveyors and bucket elevators convey the crushed stone to and from the bins and load and discharge the hopper barges used for transportation. This self-discharging barge is a unique feature.

The Gatun Dam of the Panama Canal.—Eng. Rec., Dec. 26, 1908. 2½ pp.

Describes and illustrates the proposed dam at Gatun and shows the record of borings and tests made at the dam site. Also tells of experiments made to test the materials that are available for embankment work in connection with the dam. The whole article is intended to show that the Gatun dam is feasible.

Hand Drill in Prospecting Placer Deposits.—By John P. Hutchins. Eng. & Min. Jl., Dec. 12, 1908. 4½ pp.

The writer describes the methods of drilling; driving rotation and pulling of casing; the taking of cores; and the speed of drilling. Comments on the advantages and disadvantages of hand drilling as compared with steam drilling for prospecting are made.

Comments on Handling Earth with Wheelbarrows.—Eng.-Contr., Dec. 30, 1908. 1 p.

Comments are made on the methods of using wheelbarrows on the style and kind of barrow to use, the need of new ways to track the barrow upon, the capacity of the barrow, and on the length of haul that is economic.

SURVEYING AND DRAFTING.

Blue Print Holders.—By I. P. Smith. Wood Craft, December, 1908. 1⅓ pp.

Shows dimensioned drawing and describes construction of frame for holding the prints when printing.

Cost of Reconnaissance Survey for Railway Location in Alaska in Winter.—By Fred. Lewis. Eng.-Contr., Dec. 9, 1908. 1⅔ p.

Describes character and conditions of work, gives wages, party organization, list of rations allowed, and cost of surveys. Some comments on methods, wages, etc., are made by the author.

The Rectangular System of Surveying.—By W. A. Truesdell, Jl. Assoc. Eng. Soc., November, 1908. 23 pp.

Gives historically the origin and development of the rectangular system of surveying, citing the various laws and describing the work of the various men who worked to develop the system.

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COST KEEPING AND MANAGEMENT.

System of Cost and Time Keeping in Use at the Columbus, O., Municipal Electric Lighting Plant. By G H Gamper Eng. News, Dec 3, 1908. ¾ p.

Describes in some detail the system of cost keeping employed, the forms, etc., used and the various methods of following up details that are used at the plant named. A good general article for engineers interested in cost keeping methods

MISCELLANEOUS.

Large Material Handling Plant for U. S. Government Lock Work. Earth & Rock, Dec. 1, 1908. 1 p

Describes hoisting bridge cranes which spanned the lock work and handled all material, both for excavation and concrete work.

Methods and Costs of Making Wash Borings on a Ship Canal Survey.—By A. W. Saunders. Eng.-Contr., Dec. 9, 1908. 2 pp.

Describes two types of plants and method of operating them for making wash drill borings on a survey across New York state for a ship canal. Forms for recording work and keeping costs are shown and general and also itemized comparative costs of making borings are given.

Care in Using Dynamite on the Isthmian Canal Work.—Eng. News, Dec. 3, 1908. ⅓ pp. Eng.-Contr., Dec. 9, 1908. ¾ p.

Report of decisions arrived at by engineers, steam shovel men and powder men employed on the Panama canal work as to precautions to be taken in using dynamite to reduce accidents.

Underground Insulation of Steam and Hot Water Pipes.—By Harry Gillette. Eng.-Contr., Dec. 9, 1908. ¾ p.

Points out reasons for insulation and refers to pipe tunnels, their cost and disadvantages. Vitrified Sectional Conduit is then described and its advantages explained.

Field for Office Engineers.—By D. R. Cooper. Eng.-Contr., Dec. 16, 1908. 1⅓ pp.

Points out necessity for the office engineer and the qualities required of such engineers; outlines their duties and considers their prospects.

License Laws for Engineers and Surveyors.—Eng.-Contr., Dec. 23, 1908. 1¼ pp.

Editorial arguing the impracticability of securing legislation of restrictive character which will do away with incompetent and dishonest practitioners of engineering.

Plea for the Business Training of the Engineer.—By R. A. Ross. Eng.-Contr., Dec. 30, 1908. 1½ pp.

Argues the necessity of business training for engineers and states why engineers should develop good business capacities.

The Operation of Passenger Elevators.—By R P. Bolton. Proc. Am. Soc. C E., December, 1908. 11 pp.

Shows the importance of this subject, especially in New York. Likens the operating to train service. Considers and comments on the speed and functions of passenger elevators Illustrated with diagrams

Acetylene Town Plants. By Alton D. Adams. Mun Jl. & Eng., Dec 2, 1908. 1½ pp.

Gives figures on the use of acetylene gas plants for lighting small towns.

The Municipal Engineer: His Duties and Responsibilities.—By F. J Edger. Surveyor, Nov 20, 1908 2 pp.

Presidential address delivered before the Newcastle-Upon-Tyne Association of Students of the Institution of Civil Engineers

Modern House Drainage.—By John Lawrence. Surveyor, Nov. 20, 1908. 2½ pp

A paper read before the Institute of Sanitary Engineers. It contains a number of suggestions for improvements to house drainage systems.

Some Wrinkles on Repairing Railway Picks. By T C Bagley Ry & Mar W'ld December, 1908 ⅓ p., Earth & Rock Dec 15 1908 ⅓ p

Shows various methods of welding steel points on picks and discusses relative merits

Refuse Destruction in Richmond Borough, New York City.—Mun Eng. Mag December, 1908. 6 pp.

General article describing the refuse destruction plant at West New Brighton, Richmond Borough, New York City

BOOK REVIEWS.

Masonry and Reinforced Concrete—A Working Manual of Approved American Practice in the Selection, Testing and Structural Use of Building Stone, Brick, Cement, and Other Masonry Materials, with Complete Instruction in the Various Modern Structural Applications of Concrete and Concrete Steel.—By Walter Loring Webb and W. Herbert Gibson, Chicago, Ill., American School of Correspondence. Half leather 6½x9½ ins.; pp. 444; illustrated; $3.

This volume is a text book of the correspondence school class. In its class it is deserving of praise, being both reliable and instructive. The trained engineer will find nothing with which he is not already familiar and he will not find much that the standard treaties already published give him The portion on masonry other than concrete is very meager, so meager in fact that its inclusion can be understood only on the reasoning that many of the procedures for designing walls, footings, piers, caissons, etc., apply equally to concrete and to stone and brick masonry and so the latter were included with some elementary data on brick and building stone and stone cutting to round out the titular scope of the book.

The book is divided into three parts: (1) Masonry and Concreting Materials; (2) Stone Masonry and Plain Concrete Construction; (3) Reinforced Concrete. The concrete matter in the book is good; it is not exhaustive or complete, but so far as a general examination discloses it is up-to-date and reliable, and this is all that need be asked perhaps in a book for students and beginners. These and particularly the home student will find the book a good preparation for the more comprehensive and critical study of concrete design and construction.

A Review of the Fifth Report of the Royal Commission on Sewage Disposal, 1908. By T. Aird Murray, Toronto, Ont. The Canadian Engineer. Paper 6x9 ins.; pp. 26.

Sanitary engineers not possessing the "Blue Book" containing the full report and also those not having the time or occasion to wade through its 238 pages of discussion will find this review by Mr Murray, reprinted from the "Canadian Engineer," the next best source of information on the work done. Short as the review is, its author has succeeded in epitomizing the report in a clear and comprehensive manner.

The American Practice of Gas Piping and Gas Lighting in Buildings.—By Mr Paul Gerhard, M Am. Soc M E New York McGraw Publishing Co. Cloth 6x9 ins pp 306; $3.

This book is first an argument for the utility and value of gas for illumination and other household purposes and second a manual of advice and instruction in the use of gas for residence lighting, cooking etc. It is essentially a book for the gas consumer but it will be found useful to builders, architects and others for it gives information on piping, fixtures, burners, globes location of lights, which if it were more often possessed would result in fewer poorly lighted houses and less prejudice against gas and gas companies. Indeed gas companies should feel obligated to Mr Gerhard for the excellent light in which he has placed not only their product but their practice in marketing it There are 27 chapters in the book including what has every evidence of being a very complete bibliography on gas lighting and there is not one which cannot be read with interest and profit by gas users The book is not a technical treatise though its statements are based on full technical knowledge of the subject, it does not discuss technically the manufacture of gas, or explain the intricacies of gas fitting or consider power generation It is a treatise for the layman who burns gas and kicks about his meter readings once a month

Water Power Engineering. The Theory, Investigation and Development of Water Powers. By Daniel W. Mead, M Am Soc. C E. New York: McGraw Publishing Co. Cloth, 6x9 ins.; pp. 787; illustrated, $6

This book is distinctive for its discussion of stream flow and its chapters on the evolution of the water wheel and speed regulation and governors. Professor Mead starts with the thesis that good engineering in water power development involves the investigation of stream flow and head in quite as much detail as the design and construction of plant is worked out and he makes the statement that the majority of failures in water power development have occurred from causes other than structural defects. The full discussion of run-off, rain fall, topographical and geographical conditions flood flow, head, storage and pondage, probable loads on the pump, etc., naturally follow In no other book that we know of are these subjects so fully and so carefully considered Practically all of Chapters IV to XI, inclusive, comprising some 180 pages, are devoted to presenting the studies necessary to determine the supply of water power available. Pondage and storage are more briefly discussed, only one chapter of 23 pages being devoted to this, in certain sections very important problem.

Water wheels and turbines are discussed in Chapters XII to XVI, inclusive. In Chapter XII, under the caption of Water Wheels, the author describes the evolution of the water wheel much more fully than we recall having seen it described elsewhere. This chapter, taken in connection with the historical account of water wheels in Chapter I., covers the evolution phase of the subject Chapters XIII to XVI, discuss turbine details, hydraulics of the turbine, turbine testing and the selection of the turbine Speed regulation of turbine water wheels and the water wheel governor are each given a chapter, then come chapters on selection of machinery and design of plant, examples of water power plants relation of dam and power station principles of construction of dams appendages to dams and cost value and sale of power. Professor Mead has gone very thoroughly into his subject and has produced a book which is of distinctive merit in its field

Notes on Hydro-Electric Developments.—By Preston Player New York McGraw Publishing Co Cloth 4¾x7½ ins pp 68; illustrated $1 net

This little manual has been written for the instruction of those who finance hydro-electric power developments It tells in untechnical language what information the banker capitalist or investor should obtain before putting his money into any enterprise and explains the manner of correctly interpreting this information This brief treatment of the subject from the commercial side has undoubted value for the class of readers to which it is addressed and not a few engineers would be the better engineers and promoters of hydro electric enterprises because of its reading

Electrical Illuminating Engineering—By William Edward Barrows Jr Assistant Professor of Electrical Engineering Armour Institute of Technology New York Mc-

Graw Publishing Co. Cloth; 6x9 ins.; pp. 216; illustrated; $2.

Professor Barrows has produced an excellent text book on illuminating engineering—it is not an exhaustive treatise. Beginning with a presentation of the phenomena of light and color and the author gives tables of the amount of light reflected from surfaces of various colors, amount of light absorbed by globes, the candle power intensities of the common sources of light, intensities of light required for various services, colors of different kinds of lights and the effect of colored lights on various colors. A short chapter of definitions of the common units of illumination follows, and in the two succeeding chapters photometry and photometers are discussed. Chapter III explains the principles of photometric determination of illumination intensities, and illustrates and explains concisely the various kinds and forms of photometers. Illustrations are given of most of these devices. In Chapter III spherical photometry and integrating photometers are considered. The Rousseau diagram and Dr. Kennelly's graphical construction for determining spherical candle power are illustrated and explained. The mirror photometer, the Leonard photometer and Ulbrich's spherical photometer are also described in Chapter IV. Chapter V defines and describes the standards of illuminating power and analyses the value and exactness of each. In Chapters VI to IX, inclusive, the author discusses in order incandescent lamps, arc lamps, flaming arc lamps and vapor lamps. Each kind of all these types of lamps is briefly described as to construction and operation and its life, candle power, efficiency, power consumption, best conditions of operation, adaptability, etc., are stated and analyzed. These chapters form a remarkably concise and clear summary of the latest information and knowledge concerning modern electric lamps. In Chapter X the author explains and illustrates the comparative values and effects on electric lamps of various common forms of shades and reflectors. In Chapter XI are given the methods of determining the necessary value of the candle power of a primary source of light in order to obtain the desired illumination intensity, and the calculation of the illumination when the distribution of light from the source is known. An appendix gives the current carrying capacities of various sizes of copper wire.

Coal.—Part I, Coals of the Monongahela Formation or Upper Productive Coal Measures. Part II, Chemical Analysis and Calorific Tests of the Clarion, Lower Kittanning, Middle Kittanning and Upper Freeport Coals. Geology by J. A. Bownocker, chemistry by N. W. Lord and E. E. Somermeier. Geological Survey of Ohio. Columbus, O. Cloth; 6x9 ins.; pp. 342; illustrated.

This volume on the Ohio coals is an excellent example of the work being done by our state bureaus in the study of natural resources. It consists of two parts. Part One is a discussion of the important seams of the Monongahela Formation or Upper Productive Coal Measures. These seams, it is stated, have previously been in part described, but since the reports have long been out of print, it seemed best to review the entire field. Accompanying the discussion will be found the chemical analyses and calorific tests made by Professors Lord and Somermeier. The tests made of the Pittsburg and Pomeroy seams with reference to their use in coking should be read with profit. Another feature of this part of the report is the new assignment made the Pomeroy seam. Heretofore that has always been regarded as the Pittsburg, but recent studies have demonstrated that the coal in question lies above the Pittsburg seam and is the equivalent of the Redstone of Pennsylvania and West Virginia. Credit for this determination belongs very largely to Mr. D. D. Condit.

Part Two consists of analyses and calorific tests of four seams of the Allegheny Formation or Lower Productive Coal Measures. These are the Clarion, Lower Kittanning, Middle Kittanning and Upper Freeport coals. Accompanying the results will be found sections showing the thickness and structure of the seam where sampled. In the chapter by Professor Lord, "Interpretation of the Chemical and Physical Tests on Coal," the value of coal as shown by its chemical analysis and the effects of the different constituents upon its fuel value are discussed in some detail, as are also the total and available heating values of coals.

The analytical results on the different samples are given in tabular form near the end of the chapter, the composition of the several seams compared and the variations of the seam in different portions of the state shown and discussed. The latter portion of the chapter deals with the improvement of coal by washing and gives the result of a number of tests.

The last chapter is by Professor Somermeier and discusses methods of coal sampling and also of making analyses and calorific tests. The discussion of analytical and calorific processes will prove instructive to persons interested in such lines.

The bulletin can be secured at the cost of publication, a nominal sum, by addressing the Survey.

Fluorspar Deposits in Kentucky.—With Notes on the Production, Mining and Technology of the Mineral in the United States; Also Some Data Concerning Barite Deposits. —By F. Julius Fohs. Kentucky Geological Survey, Lexington, Ky. Cloth; 7x10 ins.; pp. 296; illustrated.

This excellent report not only gives very complete data on the geology and occurrence of fluorspar in Kentucky, but it forms a valuable treatise on fluorspar mining, milling, analysis and technology generally. The chapter titles are: Production of Fluorspar; Progress of the Fluorspar Industry in 1905-6; Fluorspar and its Occurrence; Prospecting and Mining Methods; Milling Methods; Uses and Technology of Fluorspar; Methods of Analysis of Fluorin Compounds, and List of Mills, Mines and Operators. There are numerous tables and illustrations of mine workings, mills and milling and mining machinery. The Kentucky Survey deserves high praise for this study of fluorspar.

Proceedings of the Municipal Engineers of New York for 1907.—Max L. Blum, Editor. Published by the Society, 29 West 39th street, New York: Cloth; 6x9 ins.; pp. 234.

This volume of the proceedings contains besides the business proceedings of the society the text and discussions of the following eight papers read during the year: Construction Details of Reinforced Concrete Work, by De Forest H. Dixon, Secretary of Turner Construction Co.; The Geology of Lond Island and Its Practical Relation to Underground Water Supplies, by Alexander Simpson Farmer, Assistant Engineer, Aqueduct Commissioners; Some Notes on Municipal Cleaning and Refuse Destruction, by John Turney Fetherston, Superintendent of Street Cleaning, Boro of Richmond; The Relation of Sanitary Science to Municipal Engineering, by George A. Soper, Ph. D., Consulting Sanitary Expert, Public Service Commission; Traverse Work in Connection With the Triangulation of the Bronx Boro, by Edward H. Holden, Assistant Engineer in Charge of Surveys and Monumenting, Topographical Bureau, Borough of the Bronx; The Desirability of Centralized Engineering Control for New York City, by M. N. Baker; The Southern Extension of New York City, by Herman Arnold Ruge; The Designing, Making and Testing of a Telescope, by F. Kollmorgen, Optical Expert for the Keuffel & Esser Co.

Catalogs Worth Having.

Engineers and contractors should have on file the latest catalogs of machines, tools and supplies that they use. In sending for catalogs reviewed or advertised in this paper, you will confer a favor on us if you will write direct to the advertisers and state that you saw the catalog mentioned in ENGINEERING-CONTRACTING. If you are in the market for tools, machinery or supplies, tell us and we will notify promptly the leading manufacturers.

No. 1035. **Concrete Mixer.**—Chain Belt Co., Milwaukee, Wis.

This pamphlet illustrates and describes and presents the advantages claimed for this new type of non-tilting concrete mixer. Tables of sizes and capacities are given and some data on costs.

No. 1036. **Tisco Steels.**—Taylor Iron & Steel Co., High Bridge, N. J.

This handsome pamphlet of 48 pages describes the qualities of "tisco" manganese steel and points out the advantages of its use for castings for stone crusher parts, gears and pinions, sprockets, sheaves, car wheels, screens, chains, etc. Tables of sizes and other catalog data are given.

No. 1037. **Concrete Machinery.**—Besser Mfg. Co., Alpena, Mich.

This is a useful catalog for cement users. It describes and illustrates a large line of block-making machinery, special molds, concrete mixers. Some 16 pages of instructions are given for molding concrete work and operating the various machines.

No. 1038. **Chain Blocks, Electric Hoists, Trolleys and Cranes.**—Yale & Towne Mfg. Co , New York.

A 70-page catalog of blocks, hoists, trolleys and cranes for all kinds of service. The descriptions are concise and clear and the catalog data are very complete. Except the chain blocks all the machinery is electrically operated.

No. 1039. **Track.**—The Railroad Supply Co., Chicago, Ill.

This 140-page vest-pocket catalog is worth securing. It not only describes and lists a full line of track tools and supplies, but it contains some 50 pages of information and tables of the greatest service to track men and engineers of maintenance of way.

No. 1040. **Combination Traction Engine and Steam Roller.**—The Huber Mfg. Co., Marion, O.

Contractors will be interested in the combination outfit described and illustrated in this circular. "The traction wheel cleats are all interchangeable, are fastened on with bolts, and may be easily and quickly removed, leaving the wheels smooth for rolling purposes. The front truck can be quickly taken off and the roller attachment put in place, and the steam roller is then complete. When the roller has done its work, it is as quickly changed back to a traction engine, and can be used for any purpose that requires power. For instance, the engine could be kept busy crushing stone when weather conditions would not permit road work; and the contractor is enabled to arrange his work to the best advantage, and economize in time and expense. The engine will also pull the grader or scraper in the most satisfactory manner. For plowing up streets, nothing is so good as the traction engine. The speed can be regulated as required, and the motion is steady; points that are very important in doing such work."

No. 1041. **Corrugated Metal Culverts.**—The Canton Culvert Co., Canton, O.

This circular describes the construction of "Acme" corrugated culverts and gives tables of diameters, gages, thicknesses and weights. Views of culverts and culvert work are shown.

No. 1042. **Portland Cement.**—Edison Portland Cement Co., New Village, N. J.

This 64-page pamphlet describes with illustrations the Edison cement works and special processes and the methods of manufacture followed. Special fine grinding is claimed and the value of fine grinding is described and proven by numerous quotations from cement authorities. The illustrations of structures built with Edison cement are unusually comprehensive, including filtration plants, bridges, viaducts, subways, tunnels, storm relief sewers, gigantic ice piers, hollow and solid dams, skyscrapers, dwellings, garages, enormous spans for interior construction, all of which will prove that concrete has practically no limit as a building material. Some of the pictures show architectural effects and finishes which are worthy of careful study.

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A Notable Paper on Concrete Building Costs and Cost Keeping.

We give considerable space in this issue to a paper on the cost of concrete building construction. Engineers and contractors for concrete work will recognize the author of this paper as one of the most prominent engineering contractors for concrete work in the United States. The paper is, therefore, an authoritative expression of experience. It describes a method of recording and analyzing costs for concrete work and it gives itemized records of actual costs of a great variety of such work. These costs are undoubtedly valuable. Undoubtedly also they could have been further analyzed and analyzed in different terms to great advantage. In particular we should like to have seen the cost of form work stated in terms of per cubic yard of concrete and per thousand feet board measure. There is an old adage, however, that we "should not look a gift horse in the mouth," and it may well prevail in our acceptance of Mr Wason's gift of cost data. We do not know of an instance of more generous giving of its kind.

As Mr Wason truly says, these data are of the kind that the contractor usually keeps under his own hat. They seldom get beyond a few of the highest officials of the construction company. For breaking away from this policy Mr. Wason deserves the thanks of engineers and contractors, despite the fact that he deprecates the generosity of his action by claiming pure selfishness as his motive.

To our minds the motive is of deeper root than selfishness even. It goes down to the beginning of the knowledge that the special process, the secret ingredient and all their kin are in greater or less degree "pure bluff" as accounting for success in contracting. There is no secret process for successful concrete work, except honest work and good management—these are qualities free to any one to attain. As Mr. Wason pointedly remarks, "the older firms in the field have little to fear from the beginner because so much depends on personal ability as well as experience." The novice is a danger, however, when through ignorance and inexperience he bids less for work than it costs and so loses out or resorts to "skinning," which perhaps leads to accident and so discredits concrete construction in the sight of the architect and the owner.

The Preparation of Expert Testimony on Costs of Construction.

Nearly every engineer at one time or another, is called upon to testify in lawsuits involving costs of construction; and, unless guided by some previous experience as an expert witness in similar cases, an engineer is likely to come to grief, no matter how well informed he may be

If an expert testifies that a certain class of rock excavation, for example, would actually cost 80 cts. per cu. yd., he must be prepared not only to show what each and every item will cost in cents, but to specify the plant required and the daily output of each part of the plant Many engineers attempt to resist questions intended to draw out such analysis of costs, but such an attempt is fatal if the cross-examining attorney understands how to expose the weakness of cost testimony that will not stand analysis

To illustrate how weak cost testimony is unless the costs can be analyzed, let us take an example that actually occurred. The question involved was the unit cost of a reservoir embankment. An engineering witness had testified that it would cost a certain sum per cubic yard which we will call 50 cts. He refused, however, to analyze the cost into its elements, but stood out stubbornly for the total of 50 cts per cu yd as being a fair cost based upon "long experience."

This lead into the question of the experience of the witness. The witness cited the construction of several reservoirs of which he had had charge, as an engineer; but in none of these had steam shovels been employed to sufficient extent to enable the witness to cite any steam shovel data. Indeed, it developed that the witness had had very little experience with steam shovels and could give no steam shovel cost records of his own. Nevertheless, the witness had previously admitted that the work in question was of such magnitude that it would unquestionably be done with steam shovels. Furthermore, the witness admitted that the distance of transporting the earth was not the same as in any of the reservoirs he had built. Driven to explain how he could logically apply data drawn from his experience to work involving conditions varying materially from those that he had "experienced," the witness was forced to say that he had "made due allowances" for the varying conditions.

Now, this is precisely what every witness must do, for there are rarely, if ever, two pieces of construction work that are identical. Conditions vary, and due allowance must be made for the variation It is logically impossible to make an "allowance" for variations in the aggregate. Each condition must be considered by itself as to its effect upon the cost If the haul is 1,000 ft in one case and 3,000 ft. in another, the witness must show that he has made due allowance for the difference, or be discredited as to his knowledge of costs If he affirms that he has made due allowance he is immediately confronted with a question as to what the precise allowance was. In short, he is forced into an analysis, or stand discredited

It is absolutely impossible to maintain the soundness of an estimate of unit cost based upon experience, unless that experience involves at least one instance identical in every respect with the case in question.

Let the price of coal be $4 a ton on one job and $6 on another, and let all other conditions be identical, then the witness must be prepared to show what amount of coal is required per unit of work done

Let the wages of enginemen be the same on both jobs, while the wages of common laborers differ, then the witness must be prepared to show what amount of common labor is involved in each unit of work.

Let there be 1 per cent of large cobbles to be removed from the reservoir embankment before rolling and 5 per cent from another, then the witness must show that he has knowledge of the cost of removing cobbles

Clearly, no expert witness can hope to make a favorable impression in a cost case unless he is prepared to submit a

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complete analysis of the unit costs in question. The first step, therefore, in preparing to submit testimony, is to investigate each of the conditions that would affect the cost and to tabulate the various items of cost as determined by each of these conditions.

Since the magnitude of the work often determines the kind of plant required, the expert witness should itemize the plant required, and the first cost of each element of the plant. The time limit clause will usually determine the amount of plant required. Hence the necessity of considering the time element.

Having tabulated the plant and its first cost, a monthly percentage for interest, for current repairs, and for depreciation should be assigned to each class of plant. Then the daily or monthly consumption of fuel should be estimated, and a proper price per unit of fuel assigned.

The next step should be to tabulate the number of workmen of each class required to operate the plant and complete the job within the time limit. Proper wages should be assigned to each class of workmen, and an average monthly pay roll prepared.

The monthly output of this organization is then recorded and the total monthly output divided by the total monthly cost of labor and plant charges to get the net unit cost.

To the net unit cost it is usually necessary to add a certain percentage for overhead charges and miscellaneous items that are not readily eliminated otherwise.

The procedure, as above outlined, will lead to a complete and logical analysis of the unit cost, which may be typewritten and submitted as an exhibit in the case, and used by the witness both in direct and in cross-examination. It is well to memorize all the important items, rates of wages, etc., so as to meet questions in cross-examination promptly and without referring to any notes if possible. It is well always to have the salient parts of the specifications committed to memory, also the important dimensions and features shown on the plans.

In a subsequent issue we shall give some further suggestions as to the preparation of testimony and the methods of presenting it.

A Correction.

A typographical error occurred in our article of January 6, describing the new concrete mixer made by the Chain Belt Co., Milwaukee, Wis In both the captions to the article and to the illustration, the machine was described as a "new tilting" mixer, instead of as a non tilting mixer. This mixer is non tilting, as a perusal of the description makes clearly evident. The compositor changed *non* to *new*, and the error passed proofreaders and editors without being detected.

Concrete and Reinforced Concrete Section

Note: This Section is devoted to methods and costs of constructing concrete and reinforced concrete structures. It will cover the selection, testing and proportioning of concrete materials; laboratory tests of concrete; concrete mixing, transportation and placing; fabrication and placing of reinforcement, and form construction and erection. It will also contain articles on new and interesting developments in the design of reinforced concrete.

Cost of Concrete Construction as Applied to Buildings.*

The writer gives in this paper some actual job costs of various parts of building construction from his own experience. This kind of data is usually guarded with the greatest of care from every interested or curious eye outside the firm possessing it, and often even from the trusted employee of the company. It is information usually known only to the manager or owners of a construction company and kept by them under lock and key. It is not pure philanthropy on the writer's part to publish these cost data. If the selfish business motive is stated for so doing, perhaps more confidence may be placed in the figures given.

Granolithic pavements have been so long in use and so many contractors have laid them that their cost is a matter of common knowledge not only to all cement users but to the interested investing public. The result is that any contractor bidding a living profit above the actual cost of construction has a fair show of winning the job and the lowest bidder will usually make a profit. The same is true of building construction with brick and wood. Not so, however, is the case with concrete building construction. The art is too new to have methods or even designs standardized sufficiently to permit of cost data for present methods being very generally known. A great many builders are taking up this type of construction at the present time, some who are competent, many who are not. The novices under-estimate the cost and difficulties of doing good work, hence they bid unreasonably low, lose money, and to some extent demoralize the true value of proper workmanship among architects, engineers and their clients. In the writer's opinion there is no class of construction where more painstaking skill and often technical knowledge is required than in reinforced concrete. When well done the resulting building is satisfactory to the owner beyond any other material, and when poorly done it is the least desirable, even if not actually dangerous. Concrete is either good or bad. There is no halfway state, and the difference in cost of materials to the builder between perfect results and a dangerous structure is only 5 per cent. Therefore there is likely to be serious injury done to a rapidly growing industry by the novice either on account of ignorance, though coupled with honest, well meaning intent, or through skinning a job on which he is sure to lose money. Moreover, the older firms in the field have little to fear from the beginner because so much depends on personal ability as well as experience. With growing competition improvements are constantly being developed. The standard of cost is not yet fixed but is being reduced steadily. The desire of reducing the present wild bidding and having only intelligent competition as well as saving some poor builder a loss he cannot afford is the real inspiration of this paper. The author has undertaken it with the understanding that other competent writers would discuss it, so that a greater good will result.

METHOD OF COLLECTING COST DATA.

In order to have an intelligent understanding of the meaning of the figures hereinafter given, the method of collecting data will first be described. When making up an estimate of the cost of a building, in scaling the plans, it is found convenient to take off the volume of excavation and backfilling, the cubic feet of footings, foundation and wall, the square feet of forms for walls of foundations and above grade, the lineal feet of belt courses, moldings, cornices, etc., also the size of special features of exterior treatment. Similarly the superficial area of column and floor forms are measured by themselves. Concrete of each different mixture is scaled off in cubic feet and totaled separately. Steel of each kind is taken off in pounds; granolithic finished surfaces in square feet, and so on in detail every item is measured. As the work progresses it is desired to know weekly how the actual experience compares with the estimate and at completion to compile correctly the costs of each item to compare with estimate and to aid in obtaining the true cost of future structures of a similar kind. The method of accounting was developed to fit the estimate.

In the year 1898 daily time reports were designed having a number of columns for ease in sub-dividing the time of the workmen. At the head of each column the timekeeper puts index numbers or letters to show the kind of work being done, and below, the actual time the men worked. On blank spaces at the extreme right of the report the timekeeper inserts in writing the amount of each kind of work done and the amounts of the principal materials used. The experience of eight years has required no change whatever in the principles first adopted. The only change in the forms has been to increase the number of vertical columns so that a larger number of sub-divisions can be used without troubling the timekeeper to re-write the names on another sheet. At the present time ten vertical columns (Fig. 1) are used for recording time, with the names of the workmen at the extreme left, two columns being left at the right for the rate per hour and the total amount. At the beginning of a job written instructions are given as to how the work is to be subdivided into items in the reports. A standard method of classification has been adopted as follows:

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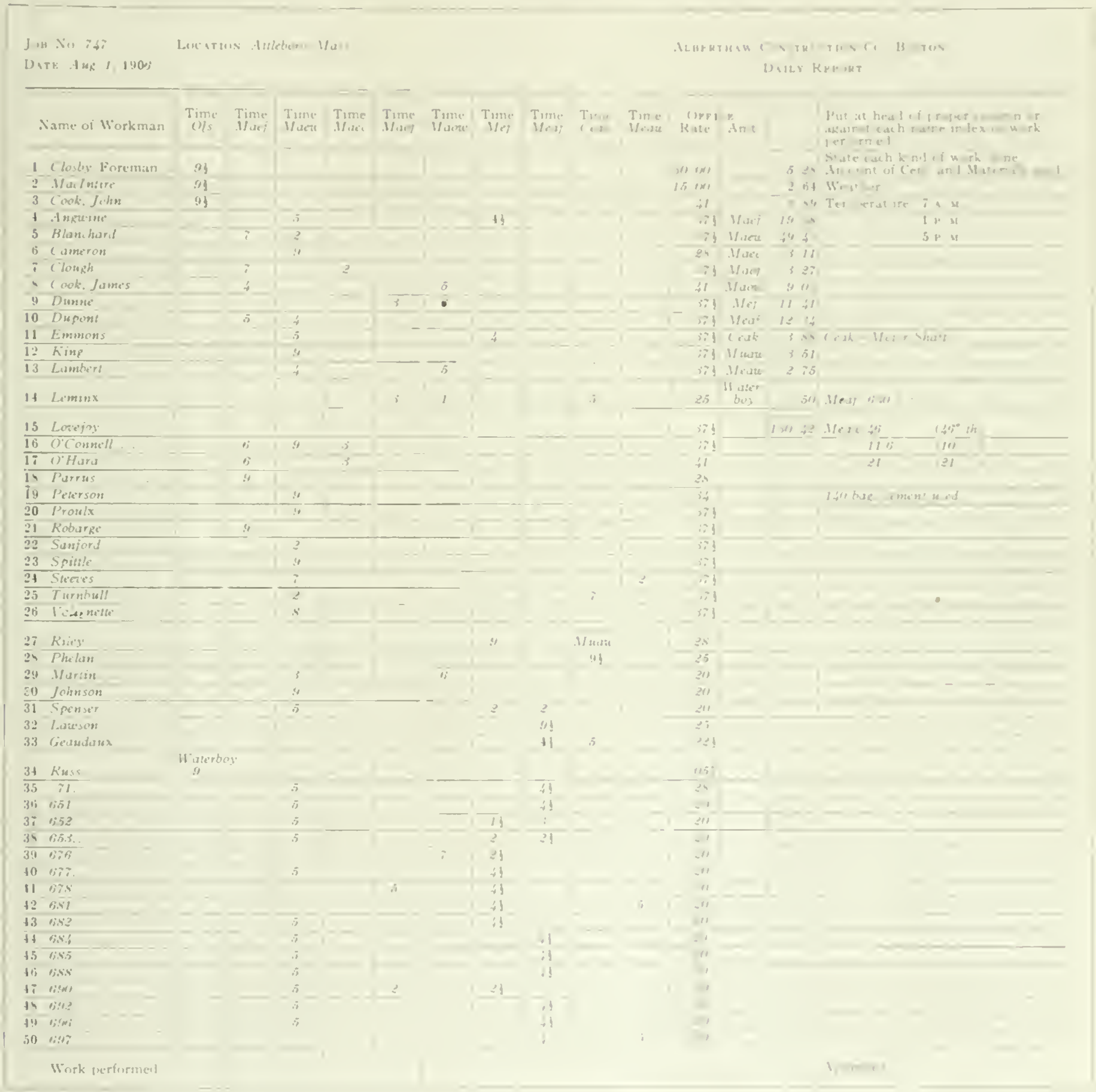
*A paper presented to the Fifth Annual Convention of the National Association of Cement Users at Cleveland, O., Jan. 11 to 16, 1909, by Leonard C. Wason, President, Aberthaw Construction Co., Boston, Mass.

The principal sub-divisions are given a capital letter. Thus, everything whatsoever relating to concrete masonry is given the index letter *M*, excavating of all kinds, including work incidental thereto, the letter *D*, all work connected with plant the letter *P*, and so on, there being only six or seven sub-divisions to indicate every building operation. To indicate the kind of work vowels are used. Thus, the vowels beginning with *a* all relate to form work, as *a*, centering complete when done by separate operations *aa*, making, *ae* is setting, *ai* is straightening up or bracing, *ao* removing after being used, and *au* cleaning up and handling ready to be used again. All labor connected with mixing and placing concrete or with handling materials for same goes under the head of *e*; all work in connection with plant receiving, erecting, taking down, shipping and repairing, is indicated by the vowel *i*. Thus *i* means receiving and setting up plant ready to work, *io* taking down, removing and shipping, and *iu* repairing. The consonants are used to indicate different parts of a structure in which certain work is done. Under classification *M*, *b* stands for footings, *c* columns, *d* foundation, *f* floors, *g* stairs, etc. Under classification *P*, *f* stands for boiler, *g* for horizontal engine, *h* for vertical hoisting engine, *j* for elevator, *m* for mixer, etc. Thus our timekeeper places at the head of a column



Job No. *747* Location *Attleboro Mass*
Date *Aug 1, 1909*

Alberthaw Construction Co. Boston
Daily Report

	Name of Workman	Time *Ofs*	Time *Maej*	Time *Maeu*	Time *Maec*	Time *Maej*	Time *Maow*	Time *Mej*	Time *Meaj*	Time *Ceak*	Time *Meau*	Office Rate	Office Amt		Put at head of proper column or against each name index of work performed
1	*Closby* Foreman	*9½*										*30 00*		*5 28*	State each kind of work done Amount of Cement and Materials used
2	*MacIntire*	*9½*										*15 00*		*2 64*	Weather
3	*Cook, John*	*9½*										*41*		[illegible]	Temperature 7 A. M.
4	*Anguine*			*5*				*4½*				*37½*	*Maej*	*19* [illegible]	1 P. M.
5	*Blanchard*		*7*	*2*								*37½*	*Maeu*	*49 4*[illegible]	5 P. M.
6	*Cameron*			*9*								*28*	*Maec*	*3 11*	
7	*Clough*		*7*		*2*							*37½*	*Maej*	*3 27*	
8	*Cook, James*		*4*				*5*					*41*	*Maow*	*9 0*[illegible]	
9	*Dunne*					*3*	[illegible]					*37½*	*Mej*	*11 41*	
10	*Dupont*		*5*	*4*								*37½*	*Meaj*	*12* [illegible]	
11	*Emmons*			*5*				*4*				*37½*	*Ceak*	*3 88*	*Ceak—Motor Shaft*
12	*King*			*9*								*37½*	*Muau*	*3 51*	
13	*Lambert*			*4*			*5*					*37½*	*Meau*	*2 75*	
14	*Leminx*					*3*	*1*			*5*		*25*	*Water boy*	*50*	*Meaj 6 30*
15	*Lovejoy*											*37½*		*150 42*	*Meac 46 (46" th*
16	*O'Connell*		*6*	*9*	*5*							*37½*			*11 6 10*
17	*O'Hara*		*6*		*3*							*41*			*21 21*
18	*Parrus*		*9*									*28*			
19	*Peterson*			*9*								*34*			*140 bags cement used*
20	*Proulx*			*9*								*37½*			
21	*Robarge*		*9*									*37½*			
22	*Sanford*			*2*								*37½*			
23	*Spittle*			*9*								*37½*			
24	*Steeves*			*7*							*2*	*37½*			
25	*Turnbull*			*2*						*7*		*37½*			
26	*Ve*[illegible]*nette*			*8*								*37½*			
27	*Riley*							*9*		*Muau*		*28*			
28	*Phelan*									*9½*		*25*			
29	*Martin*			*3*			*6*					*20*			
30	*Johnson*			*9*								*20*			
31	*Spenser*			*5*				*2*	*2*			*20*			
32	*Lawson*								*9½*			*25*			
33	*Geaudaux*								*4½*	*5*		*22½*			
34	*Russ*	*Waterboy 9*										*05*			
35	*71*			*5*					*4½*			*28*			
36	*651*			*5*					*4½*			*20*			
37	*652*			*5*				*1½*	[illegible]			*20*			
38	*653*			*5*				*2*	*2½*			*20*			
39	*676*						*7*	*2½*				*20*			
40	*677*			*5*				*4½*				*20*			
41	*678*					*5*		*4½*				*20*			
42	*681*							*4½*			*5*	*20*			
43	*682*			*5*				*4½*				*20*			
44	*684*			*5*					*4½*			*20*			
45	*685*			*5*					*4½*			*20*			
46	*688*			*5*					*4½*			[illegible]			
47	*690*			*5*		*2*		*2½*				*20*			
48	*692*			*5*					*4½*			[illegible]			
49	*696*			*5*					*4½*			*20*			
50	*697*								[illegible]		*5*	*20*			

Work performed

Approved

Fig. 1—Blank for Daily Report of Labor Cost of Concrete Work.

when he is reporting concrete floors, for the placing of forms *Maaf*, for concrete *Meaf*. If a mixer is being set up ready to work the report would read *Pim* and later if it was repaired it would be reported under *Piem*.

This is not so complicated to use as it may appear to read, and experience has proved that every man who knows enough to keep time can use the system with a few days' experience. The principle is to make the least amount of clerical work to the timekeeper on the job, as they have plenty of other work to do. In addition to sub-division of time as above set forth, it is the duty of the timekeeper to report the number of barrels of cement mixed in a day, which is usually done by the man in charge of the mixer counting the empty bags, and in addition the actual volume of concrete measured in place. From this, knowing the proportions, it is a very simple matter to obtain the amount of sand and stone used and also to see if the right amount of cement is being used. Carpenter work on forms is reported by the number of square feet of surface in contact with the concrete erected. Thus walls are measured two sides without deducting doors and windows, as it is usual to let the form work run straight across these unless it is impossible on account of mouldings, in which case the framing of the opening will cost as much as the form work omitted. Beam floors are measured around the perimiter of the beam and the flat surface of the panel and around the perimiter of girders. No deduction is made for the loss of area by the intersection of beams and girders, and small openings in the floor are not deducted. Anything as large as an elevator or stairway is usually deducted. Form work for columns is measured for entire area of surface contact between wood and cement, all four sides. These reports are made out on the job daily and sent to the office. The bookkeeper works these reports up into units of measurement, as cost of labor per cubic foot of concrete and number of cubic feet of concrete per barrel of cement, number of square feet of form work erected, etc., and from this it is easy to obtain the unit costs hereinafter given. The bookkeeper can take the reports of four or five jobs, employing in the aggregate 500 or 600 men, and in a single day work up the complete report for a week's time; thus it will be seen that there is really little extra labor involved in the subdividing of reports into a useful form over merely reporting the time so that the payroll can be accurately made. The system employed has appeared of sufficient value to others to warrant its being briefly outlined in Gillette's "Hand Book of Data," pages 14, 15, and 19, and a description of it also appeared in ENGINEERING-CONTRACTING of March, 1906.

Job No. 747.
Date May 24th, 1906. Mill, Tappan Bros., Attleboro, Mass.

	Proposal.	Actual Cost.	Per. Cu. Ft.	Profit.	Loss.	Per Ct.
Total	$35,164.55	$31,330.48	......	$3,834.07	$.......	11
Excavate	790.00	823.18	.021	....	33.18	..
Footings and Fr	1,738.00	1,033.57	.137	704.43	....	..
			Per sq. ft.			
Exterior walls	1,955.00	2,162.02	.190	....	207.02	..
Wall and Fr. centers	1,520.00	3,630.08	.125	....	2,110.08	..
Floors, 6⅜" thick	8,883.00	6,542.16	.339	2,338.84	....	..
Roof 5¼" thick	2,869.00	1,713.51	.237	1,155.49	....	..
			Per l. ft.			
Columns, 20x20"	832.00	676.65	1.470	155.35	....	..
Stairs	883.00	910.35	.912	....	27.35	..
			Per sq. ft.			
Tool surface	469.00	636.53	.056	....	167.53	..
Ornaments and cornice	348.00	164.33	....	183 67	....	..
Ventilators on roof	44.00	35.64	....	8.36	....	..
			Each.			
Set windows and door frames	852.00	729.99	2.19	122.01	....	..
			Per sq. ft.			
Interior partitions	1,770.25	1,656.35	.189	133.90	....	..
Bolts and iron work	253.00	257.06	....	....	4.06	..
Stair railing and grill	387.00	654.00	....	....	267.00	..
			Per M.			
Screens and setting	1,086.00	835.12	52.17	250.88	....	..
2" Spr. plank and laying	2,839.00	1,431.69	33.30	1,407.31	....	..
7-8"Maple plank and laying	1,738.00	1,788.88	89.44	....	50.88	..
Motor shaft	379.50	533.19	98.89	....	153.69	..
Motor shaft found	98.00	70.07	.....	27.93	153.69	..
Roofing and conductors	1,255.00	1,026.06	.....	288.94	....	..
			Per sq. ft.			
Paving	1,009.00	647.54	.094	361.46	....	..
Retaining wall—						
Centers, per sq. ft	....	......	.211	....	....	..
Concrete, per cu. ft	429.00	316.90	175	112.10	....	..
Painting	400.00	375.00	....	25.00	....	..
Steel footings and walls	300.00	218.91	....	81.09	....	..
Plant frt., etc	1,860.00	2,271.73	....	....	411.73	..
Bond	100.00	120.00	....	....	20.00	..
Extras	77.80	67.97	....	9.83	....	..

Fig. 2—Master Card, Giving Complete Cost of a Job.

Materials received on the job are reported on cards especially printed for the purpose, listing the principal materials which are reported, in order to save work of the timekeeper in reporting materials accurately.

When a job is entirely completed and the ledger account is closed, a master card is worked out giving the complete history of the cost. On one side of the card are written the items which went into the original estimate, such as excavation, backfillings, footings, foundations, columns, floors, walls, stairs, etc., etc. In parallel columns is placed the actual amount of the estimate with the actual experience, reduced to cost units such as cubic feet, square feet of form work, etc., and the percentage of profit or loss between the estimate and actual results. On the reverse side of the card the principal items are worked out more in detail. Thus form work is reduced to cost of labor, lumber and nails, wire or other sundries used in the forms per square foot of surface. Concrete is itemized into the superintendent's general labor, labor of mixing and placing, cost of cement, sand, stone; miscellaneous expenses such as teaming, plant and other general items, reduced to cubic feet measurement, which makes the total cost of the concrete in place in each division of the building itemized for ready reference when making up future estimates on work of a similar character. An example of this form is given by Fig. 2.

It is well known that the cost of materials and labor in different parts of the country vary somewhat. Having the unit items all sub-divided as above stated into their elementary parts, it is an easy matter after determining the cost of materials in any locality to make the exact corrections to the results obtained on a previous job. Similarly, when a difference in the rate per hour for wages is known, if the same efficiency is obtained from the men it is very easy to make a correction, or if the efficiency varies, judgment must be applied to determine the correct rate to use. It has been the writer's experience that although the rate of wages and cost of materials vary somewhat in different parts of the country, the variations frequently offset one another so nearly that the sum total of the unit cost obtained in one place may be used in another, very seldom needing correction. For instance, within one month, after careful investigation, a bid was made up on a structure at San Juan, Porto Rico, using the same unit costs as for a building in Boston. In the report that is given, the costs relate to strictly first class material and workmanship in every case, as it has been the endeavor of the writer to establish and maintain one standard for all work. The variations in cost due to different mixtures of concrete can easily be allowed for by reference to the table on page 133 of the "Proceedings of the Fourth Annual Convention of this Association" (Eng.-Contr., Feb. 19, 1908, p. 109). In general I would say that the standard mixture for all floors has been either 1-3-6, or 1-2-4 if the floor is subjected to extremely heavy loads and service. Walls are mixed 1-3-6 and columns usually 1-2-4; in some cases where they are very heavily loaded a richer mixture is used. As these mixtures are common to nearly all construction the costs here given may be applied with little danger of error from neglecting the mixture on any work. Of course it can readily be understood that in the large number of jobs which have entered into the averages given, there being as many as 18 in the case of beam floors, different methods of conducting the work have been used and many different foremen. Therefore, while the general average is doubtless safe for any work of an average character, some latitude may be allowed the judgment in determining whether any specific case is likely to be difficult, easy or average. The writer has found quite a difference, for instance, in cost of identical work handled by different foremen, due to the personal equation of their painstaking supervision and ability.

In the accompanying tables only typical jobs are given, whose results are correctly known. The results of a number of jobs have been spoiled by a change of timekeeper during the progress of the work, the new man missing for a day or two the proper classification or some other such small matter. It appears to the writer, moreover, that the results from a few typical jobs would be of more interest than a mass of figures from all kinds, some of which would be of no value. Enough are given for a fair average, except in the case of long span flat slab, which is, by comparison, a recent type of construction. The figures for the highest, lowest and average totals in the fourth and last columns are taken from the vertical column in which they stand and have no relation to the other figures in their horizontal line.

TABLE I.—COST OF CONCRETE COLUMNS.

	Forms per square foot				Concrete per cubic foot						
Location.	Carpenter labor $	Lumber $	Nails and wire $	Total $	Concrete labor $	Gen labor $	Cement $	Aggregate $	Team and misc $	Plant $	Total. $
Office building, Portland, Me.	.133	.039	.001	.173	.061	.004	.087	.084	.012	[illegible]	.273
Coal pocket, Lawrence, Mass.	.057	.024	.001	.082	.166	.005	.07[illegible]	.041	.008	.016	.307
Mill, Southbridge, Mass.	.097	.082	.002	.181	.073	.056	.107	.037	.027	.03[illegible]	.328
Mill, Attleboro, Mass.	.093	.022	.001	.116	.110	.014	.062	.058	.013	.034	.271
Mill, Southbridge, Mass.	.080	.056	.001	.137	.108	.048	[illegible]	.047	.013	.034	.31[illegible]
Coal pocket, Hartford, Conn.	.098	.047	.002	.147	.089	.043	.064	.055	.017	.013	.256
Garage, Brookline, Mass.	.071	.051	.002	.124	.070	.028	.072	.058	.041	[illegible]	[illegible]
Warehouse, Portland, Me.	.118	.016	.001	.135	.087	.027	.087	.070	[illegible]	[illegible]	[illegible]
Textile mill, Lawrence, Mass.	.061	.013	.001	.075	.095	.019	.109	.027	.018	.017	.28[illegible]
Highest	.133	0.82	.002	.181	.166	.056	.109	.084	.041	.034	.340
Lowest	.057	.013	.001	.075	.064	.003	.062	.027	.008	.017	.271
Average of 9	.082	.036	.001	.130	.096	.027	.087	.049	.021	[illegible]	.301

TABLE II.—COST OF BEAM FLOORS OF REINFORCED CONCRETE.

	Forms per square foot.				Concrete per cubic foot						
Location.	Carpenter labor. $	Lumber. $	Nails and wire $	Total. $	Concrete labor. $	Gen labor $	Cement $	Aggregate $	Team and mis $	Plant $	Total $
Power house, Greenfield	.165	.107	.003	.275	.143	.020	.109	.101	.008	.016	.397
Tar well, Springfield	.064	.041	.002	.107	.076	.005	.026	.075	.013	.040	.335
Mills, Greenfield, Mass.	.106	.061	.004	.171	.077	.011	.109	.086	.007	.055	.345
Car barn, Danbury, Conn.	.044	.051	.001	.096	.128	.013	.086	.071	.011	.010	.319
Coal pocket, Lawrence, Mass.	.072	.039	.002	.113	.056	.004	.073	.041	.009	.019	.202
Mill, Southbridge, Mass.	.067	.062	.002	.131	.137	.029	.191	.051	.038	.014	.460
Mill, Attleboro, Mass.	.062	.032	.002	.096	.071	.023	.098	.062	.021	.055	.33[illegible]
Bridge, Plymouth, Mass.	.047	.050	.001	.098	.078	.019	.100	.040	.027	.010	.247
Garage, Newton, Mass.	.104	.033	.002	.134	.116	.020	.121	.084	.038	.010	.394
Mill, Southbridge, Mass.	.057	.051	.001	.109	.119	.027	.132	.037	.013	.034	.362
Coal pocket, Hartford, Conn.	.060	.033	.001	.094	.047	.023	.081	.055	.017	.013	.236
Garage, Brookline, Mass.	.105	.038	.002	.145	.160	.032	.088	.058	.041	.020	.399
Filter, Lawrence, Mass.	.048	.032	.001	.081	.102	.016	.085	.054	.012	.032	.3[illegible]1
Storehouse, Chelsea, Mass	.064	.043	.002	.109	.153	.035	.115	.068	.052	.020	.443
Warehouse, Portland, Me.	.037	.029	.001	.067	.186	.030	.096	.069	.043	.046	.470
Textile mill, Lawrence, Mass	.045	.042	.001	.088	.130	.013	.071	.037	.025	.010	.286
Textile mill, Lawrence, Mass.	.053	.033	.001	.087	.116	.033	.194	.049	.035	.015	.442
Chapel, Portland, Me.	.053	.027	.002	.082	.100	.008	.127	.091	.041	.010	.377
Highest	.165	.107	.004	.275	.186	.035	.194	.101	.052	.055	.470
Lowest	.037	.027	.001	.067	.047	.004	.071	.037	.007	.010	.202
Average of 18	.070	.045	.002	.116	.111	.020	.106	.063	.027	.024	.354

TABLE III.—COST OF FLAT SLAB FLOORS

	Forms per square foot.				Concrete per cubic foot						
Location.	Carpenter labor. $	Lumber $	Nails and wire. $	Total. $	Concrete labor $	Gen labor $	Cement $	Aggregate $	Team and misc $	Plant $	Total $
Office building, Portland, Me	.078	.039	.001	.118	.043	.004	.087	.084	.012	.022	.252
Fire station, Weston, Mass	.067	.038	.003	.108	.103	.007	.092	.053	.026	.039	.320
Church, Boston, Mass	.067	.037	.002	.106	.146	.017	.109	.072	.020	.010	.374
Highest	.078	.039	.003	.118	.146	.017	.109	.084	.026	.039	.374
Lowest	.067	.037	.001	.106	.043	.004	.087	.053	.012	.010	.252
Average	.071	.038	.002	.111	.097	.009	.096	.070	.019	.024	.315

The general averages on form work in the foregoing tables of forms per square foot of surface contact—namely, columns $.13, floors with reinforced concrete beams $.116, flat floors without beams $.111, short span slabs between steel beams including the fireproofing on the sides of the beams $.095, walls exposed to view above ground $.128, foundation walls $.103, mass foundations $.093—are, the writer believes, all higher in price than is usually believed to be a fair cost by the majority of builders. It is upon the success of handling forms that good results financially depend. In regard to concrete labor is the variable item which must be carefully considered. Any one of intelligence can make a careful estimate of the materials to be used, but note the average prices per cubic foot of labor—namely, for columns $.123, beam floors $.131, flat floor $.106, floors between steel beams $.121, walls $.106, foundations $.091 and mass work in connection with buildings $.052; not until the last item is reached is a price obtained in experience

TABLE IV—COST OF CONCRETE SLABS BETWEEN STEEL BEAMS

	Forms per square foot.				Concrete per cubic foot						
Location.	Carpenter labor. $	Lumber $	Nails and wire $	Total. $	Concrete labor $	Gen labor $	Cement $	Aggregate $	Team and misc $	Plant $	Total $
Bleachery, E. Hampton	.054	.027	.002	.083	[illegible]	.007	.137	.07[illegible]	.012	.046	.367
Machine shop, Milton, Mass.	.087	.027	.003	.117	.090	.033	.114	.075	.016	[illegible]	.462
Foundry, N. Britain, Conn.	.078	.016	.002	.126	.095	.021	.076	.078	[illegible]	[illegible]	.296
Stable, Boston, Mass.	.064	.012	.001	.077	.101	.019	.129	.070	.020	.015	.374
Residence, Milton, Mass.	.110	.071	.003	.184	.105	.048	.132	.080	.053	.010	.428
Power House, Pittsfield, Mass	.029	.030	.001	.060	.131	.008	.123	.068	.013	.010	.373
Laundry, Boston, Mass.	.058	.024	.001	.083	.092	.021	.098	.089	.022	.010	.332
Prison, Portsmouth, N. H.	.068	.017	.001	.086	.073	.005	.208	.075	.006	.010	.377
Paper mill, Mittineague	.097	.071	.002	.170	.144	.033	.113	.062	.027	.010	.419
Power house, Quincy, Mass	.047	.025	.001	.073	.073	.021	.159	.085	.064	.02[illegible]	.422
School, Waltham, Mass.	.029	.028	.001	.058	.138	[illegible]	.102	.078	.018	.015	.360
Foundry, Providence, R. I.	.028	.020	.001	.049	.084	.012	.114	.026	.026	.010	.272
Foundry, Providence, R. I.	.043	.021	.001	.065	.111	.010	.128	.029	.029	.01[illegible]	.317
Highest	.110	.071	.003	.184	.144	.048	.208	.080	.064	.046	.428
Lowest	.028	.012	.001	.049	.073	.005	.076	.026	.004	.010	.272
Average	.061	.032	.002	.095	.102	.019	.128	.068	.024	.017	.359

which, according to the observation of the writer, the majority expect to obtain in building work in general. Many men who have had wide experience in handling large quantities of concrete in mass have at times attempted a lighter type of construction and been greatly surprised at the large expense connected therewith. It has come to the writer's notice a number of times that men with this experience have added 50 per cent to 100 per cent to the cost of mass work and felt that they were amply covered for light structural work. The fallacy of this can be seen by a very recent experience of the writer's. In building a dam this past year across the Connecticut River about 5,500 cu. yds. of concrete were placed. Cement and aggregates were received on a bridge abutment 26 feet above the river. Aggregates were dumped upon an inclined chute where they were to be washed, and from the end of the chute they fell into bins, from which they were drawn through measuring hoppers into a mixer and dumped from this into tram cars 4 ft. above the water. The total expense for labor of washing, charging, mixing and dumping into the cars was only $.12 per cubic yard and for moving it in cars an average distance of 700 ft., dumping and placing was only $.30 per cu. yd., or a total cost of $.0155 per cu. ft. The table of steel omits entirely the first cost of the material. After it is received at the site of the work in the shape sold by the manufacturer, these prices cover the cost of fabricating into units for columns or beams, bending the stirrups, placing and all incidentals whatsoever prior to the actual embedding in concrete. In the case of the highest cost, a coal pocket, there was very limited storage space, 1¼ in. bars had to be bent diagonally so as to pass over the top of the support at columns, and there were numerous stirrups, all of which had to be made by hand. The job was too small to justify any mechanical arrangement for bending or for handling material. The next highest, office building, Portland, Me., there was a sufficient amount to require proper machinery. The hoops for columns were all welded. The vertical bars were all wired inside of these hoops. There was a mushroom head of bent and circular bars wired together at the top and great numbers of long bars of small section spread in all directions over the floor. The lowest price, filter at Lawrence, was made entirely of straight bars placed loose, the only expense being cutting them in a hand shear to length and placing them.

TABLE V.—COST OF BUILDING WALLS ABOVE GRADE.

	Forms per square foot.				Concrete per cubic foot.						
Location.	Carpenter labor.	Lumber.	Nails and wire.	Total.	Concrete labor.	Gen. labor.	Cement.	Aggregate.	Team and misc.	Plant.	Total.
	$	$	$	$	$	$	$	$	$	$	$
Fire station, Weston, Mass	.116	.038	.004	.158	.100	.007	.069	.053	.026	.039	.294
Mill, Greenfield, Mass	.062	.038	.002	.102	.060	.011	.084	.086	.007	.055	.303
Waterworks, Waltham, Mass	.137	.024	.001	.162	.146	.007	.058	.057	.014	.047	.329
Coal pocket, Lawrence, Mass	.118	.056	.002	.176	.042	.004	.073	.043	.009	.019	.190
Mill, Attleboro, Mass	.103	.024	.001	.128	.129	.018	.074	.048	.017	.043	.329
Coal pocket, Hartford, Conn	.096	.047	.002	.145	.118	.052	.097	.055	.017	.013	.350
Filter, Lawrence, Mass	.046	.032	.001	.079	.046	.017	.083	.054	.012	.032	.244
Italian garden, Weston, Mass	.101	.073	.002	.176	.102	.008	.105	.081	.019	.010	.325
Stable, Beverly, Mass	.099	.030	.002	.131	.078	.019	.071	.062	.018	.010	.258
Residence, N. Andover, Mass	.078	.016	.001	.095	.096	.014	.046	.050	.008	.010	.174
Observatory, Milton, Mass	.056	.038	.002	.096	.095	.012	.060	.187	.058	.005	.417
Office, Boston, Mass	.105	.030	.002	.137	.096	.033	.066	.114	.066	.005	.380
Tunnel, Boston, Mass	.112	.045	.005	.162	.126	.016	.066	.106	.077	.005	.330
Hospital, Waltham, Mass	.058	.028	.001	.087	.089	.017	.034	.063	.023	.010	.236
Residence, Boston, Mass	.108	.036	.001	.145	.110	.015	.077	.069	.026	.005	.446
Coal pocket, Providence, R. I	.087	.020	.001	.108	.052	.005	.102	.090	.015	.010	.274
Italian garden, Brookline, Mass	.064	.027	.001	.092	.048	.011	.080	.071	.019	.010	.239
Highest	.135	.073	.005	.176	.146	.052	.105	.187	.077	.055	.446
Lowest	.046	.016	.001	.079	.042	.004	.034	.043	.007	.005	.174
Average of 17	.085	.036	.002	.128	.090	.016	.073	.076	.025	.019	.301

TABLE VI.—COST OF FOUNDATION WALLS.

	Forms per square foot.				Concrete per cubic foot.						
Location.	Carpenter labor.	Lumber.	Nails and wire.	Total.	Concrete labor.	Gen. labor.	Cement.	Aggregate.	Team and misc.	Plant.	Total.
	$	$	$	$	$	$	$	$	$	$	$
Filter, Warren, R. I	.103	.048	.004	.155	.062	.037	.086	.068	.012	.031	.296
Tar well, Springfield	.071	.031	.002	.104	.040	.015	.094	.075	.013	.040	.277
Tunnel, New Bedford	.048	.045	.001	.094	.213	.019	.203	.092	.057	.015	.599
Filter, Exeter, N. H	.124	.067	.002	.193	.064	.021	.071	.116	.034	.019	.325
Filter, Lawrence, Mass	.058	.042	.001	.101	.046	.017	.083	.054	.012	.032	.244
Theatre, Portland, Me	.081	.024	.003	.108	.112	.013	.073	.078	.003	.020	.303
Warehouse, Portland, Me	.053	.009	.001	.063	.040	.019	.060	.070	.029	.017	.235
Residence, N. Andover	.047	.019	.001	.067	.108	.006	.082	.045	.015	.010	.266
Filter, Lawrence, Mass	.048	.035	.002	.085	.055	.006	.039	.027	.011	.010	.148
Residence, No. Andover	.065	.019	.001	.085	.087	.012	.072	.045	.013	.010	.239
Retaining wall, Naugatuck, Conn	.134	.047	.001	.182	.097	.018	.056	.032	.022	.010	.235
Hospital, Waltham, Mass	.048	.028	.001	.077	.043	.019	.038	.063	.026	.010	.199
Greenhouse, Brookline, Mass	.032	.035	.001	.068	.051	.007	.078	.043	.013	.010	.202
Hotel, Brookline, Mass	.037	.018	.001	.056	.043	.002	.080	.054	.010	.010	.199
Highest	.134	.048	.004	.193	.213	.037	.203	.116	.057	.040	.599
Lowest	.032	.009	.001	.056	.040	.002	.038	.027	.003	.010	.148
Average	.068	.033	.002	.103	.076	.015	.080	.062	.019	.017	.269

TABLE VII.—COST OF FOOTING AND MASS FOUNDATIONS.

	Forms per square foot.				Concrete per cubic foot.						
Location.	Carpenter labor.	Lumber.	Nails and wire.	Total.	Concrete labor.	Gen. labor.	Cement.	Aggregate.	Team and misc.	Plant.	Total.
	$	$	$	$	$	$	$	$	$	$	$
Power house, Greenfield	.119	.077	.002	.198	.065	.020	.098	.092	.008	.016	.299
Eng. foundation, Taunton, Mass	.054	.025	.001	.080	.045	.002	.065	.048	.004	.017	.181
Head gates, Shawmut, Me	.071	.043	.003	.117	.033	.001	.074	.099	.003	.014	.224
Canal, Lowell, Mass	.039	.025	.001	.065	.025	.011	.080	.078	.004	.042	.240
Foundation, Provincetown	.069	.043	.002	.114	.039	.004	.073	.099	.011	.049	.275
Dam, Merrimack, N. H	.066	.037	.003	.106	.081	.008	.090	.055	.008	.031	.273
Foundation, Boston, Mass	011	.006	.001	.018	.035	.004	.061	.072	.006	.010	.188
Eng. foundation, Boston, Mass	.095	.039	.003	.137	.037	.013	.061	.084	.013	.015	.223
Gas holder, Springfield	.034	.031	.002	.067	.043	.001	.061	.068	.005	.010	.188
Foundation, Providence, R. I	.016	.011	.001	.028	.051	.002	.047	.076	.010	.010	.196
Highest	.119	.077	.003	.198	.081	.020	.098	.099	.013	.049	.275
Lowest	.016	.006	.001	.018	.025	.001	.047	.043	.003	.010	.181
Average of 10	.057	.034	.002	.093	.045	.007	.071	.077	.007	.021	.229

In Fig. 2 is given an exact copy of a "master card" which gives the complete financial history of the job when it is finally completed. The first column, which is blank, is occasionally used for an estimate of the first cost, the proposal including the profit as well as the estimated actual cost. It will be seen that on some items a loss was incurred, as well as a profit on others, showing that it is difficult, even on work which a company is fairly experienced on, to reach the right price on everything, and also that when slight changes are made by the owner or architect they often entail heavy loss, even though the changes appear to be extremely trivial. Take the case of the external walls. The owners furnished the window frames and sash, which were all of metal. The original design was for a frame with two sash, which could easily be put into a 6 in. wall. They later decided, for greater fire protection, to use four sash. This required an 8 in. wall instead of a 6 in., and as will be seen in the picture the form work on the inside had to be built inward and then the space under the windows paneled to save material. To save making a very narrow panel at the side of the window, which would cost more than the concrete saved, the space was filled up solid so that the columns appear to be wider than they were actually figured. This slight change, which did not appear great at the time, when the job was entirely complete showed that the concrete on the walls showed an actual loss instead of profit and that the form work cost more than twice what was originally estimated that it should cost.

Regarding the tooling of wall surfaces, we originally planned to do this when the cement was less than ten days old, but on account of the various changes forms had to be left on a considerably longer time and it was inconvenient to tool the surface until the cement was so thoroughly set that the cost of dressing was considerably greater than was first anticipated. Again, by reference to the ⅞-in. maple floor which was placed upon the concrete construction, a cost of $89.11 per M. ft. B. M. will be observed, and by reference to the details on the back of the card it will be seen that repairing floor cost $218.50, or $12.12 per thousand. This was due to the fact that the owners did not deliver or set the window sash at the time agreed and therefore the maple floors lay exposed to the weather in the building for several weeks, swelled and after laying shrunk, leaving large cracks which the owners insisted on being filled before they would accept the work. These indicate how matters which appear trivial at the time may cause serious loss if overlooked.

As seen by the large list of items entering into the estimate as given by this master card, there are various items of cost entering into the construction besides those which are enumerated.

TABLE VIII. STEEL.

Location.	Weight. Tons.	Cost of Handling.	Cost per Ton.
Office building, Portland, Me	324½	$5,115.32	$15.76
Fire station, Weston, Mass.	8½	40.26	4.74
Mill, Chelsea, Mass.	65¼	548.81	8.41
Coal bins, Dalton, Mass	8½	61.75	7.26
Dam, Auburn, Me.	55	506.76	9.18
Filter, Warren, R. I.	19	102.59	5.40
Tank, Lincoln, Me.	8½	69.38	8.16
Tar well, Springfield	15½	59.21	3.82
Monument, Provincetown	24½	136.84	5.58
Mill, Greenfield	92¾	1,232.01	10.29
Machine shop, Milton, Mass	20¼	177.16	8.75
Coal pocket, Lawrence, Mass.	28	461.16	16.47
Mill, Southbridge	53½	142.76	2.67
Mill, S. Windham, Me.	293	3,079.60	10.51
Mill, Attleboro, Mass.	49½	286.02	5.78
Garage, Newton, Mass.	20	86.55	4.33
Mill Southbridge, Mass.	30	100.02	3.34
Coal pocket, Hartford, Conn.	195	2,316.60	11.88
Filter, Lawrence, Mass.	44½	112.84	2.54
Warehouse, Portland, Me.	62	462.99	7.47
Standpipe, Attleboro, Mass.	199½	1,547.00	7.75
Highest	..	......	16.47
Lowest	..		2.54
Average of 21	.	......	8.52

Earth and Rock Section

Note: This Section is devoted to methods and costs of excavating earth and rock and building embankments. It will cover the grading of roads and railroads, diking and canal work, dredging, building reservoirs and earth dams, sewer and water pipe trenching, quarrying, etc.

Reducing the Cost of Tunnel Work With Blasting Gelatine.

During the past year blasting gelatine has been used with great success in tunnel excavation. One tunnel in particular has demonstrated its efficiency.

In February, 1908, the contractor, Mr. A. E. Carlton, started work in driving the Cripple Creek drainage tunnel in Colorado. He worked two shifts. The rock was a close grained, tough granite, being hard to blast. Holes 10 ft. deep were drilled 2½ ft. on each side of the center line at such an angle as to make them nearly meet on the center line. In blasting heavy charges of 60 per cent gelatine dynamite was used, and it was necessary, in some cases, to fire these holes several times in order to cut out the holes. For these reasons it was found very difficult to blast the rounds quickly, thus making it almost impossible to drill down, fire and throw back the muck twice in 24 hrs. Up to the end of August the best month's work was 301 ft. of tunnel driving. It was thought that greater progress could be made by obtaining a more forceful explosive.

At the beginning of September it was decided to try the use of Du Pont blasting gelatine. Accordingly some of the explosive was bought and the holes loaded with it, using the same amount for a hole as had been used of the 60 per cent dynamite. The results were surprising. Every pane of glass in the engine house and the blacksmith shop, although outside the tunnel entrance and almost 3,000 ft. from the blast, was shattered. Damage was also done to a 24 in. ventilator and 6 in. air line pipe. The contractor profited by this experience and after a few trials obtained very satisfactory results by loading the holes with from four to eight 1¼x8 in. cartridges of blasting gelatine in the points of the holes, and six or seven 1½x8 in. cartridges of 60 per cent gelatine dynamite on top of this with tamping to the face. The detonator or a No. 20 blasting cap was placed in the top cartridge of the blasting gelatine.

By using the blasting gelatine the cut was taken to the back of the holes with two shots. The first shot blew out about half of the cut and broke back and chambered the cut holes so a pocket was formed where the two holes came close to each other, large enough to hold from 15 to 20 cartridges of the 60 per cent gelatine dynamite for the second shot. As this second charge was directly behind the rock to be removed, and the face had already been shot down, the gelatine dynamite never failed to bring down the remainder.

Occasionally one cartridge of blasting gelatine was also used in the point of each of the "relief cut" holes, but usually a charge of 60 per cent gelatine dynamite was all that these holes required. The remainder of the round, including side or rib, top and bottom or lifter holes, was charged with 50 per cent gelatine dynamite.

When the tunnel was measured up at the end of September it was found that 353 ft. had been driven in 25 working days. This was a gain over the best previous month's record of about 17 per cent. This was obtained with practically no increase in cost, as the extra cost of the explosive was offset by the reduction in the amount used. We are indebted to Mines and Minerals for these data.

Drilling Blast Holes with a Hydraulic Giant and the Cost of a Hydraulic Fill Dam.

We are indebted to Mr. Donald I. Campbell, mining engineer of the Royal Societies Club of London, England, and the "Mining and Scientific Press" for the data upon which the following article on a hydraulic fill dam is based.

The dam was built for a small reservoir of 2,000,000 gals. capacity, and was located in California. The material for the dam was sluiced into place with a No. 1 giant with 2 and 2½ in. nozzles. This giant complete cost $70. A 4 in. centrifugal pump furnished the water. The water was available under a 10 ft. head and by means of a direct connected 30 H.P. motor the pressure was increased to 15 lbs. per sq.

in. The consumption of water was 425 gals. per minute.

The material washed down was obtained from the reservoir site, so as to increase its capacity. The rock was a decomposed porphyry. In order to sluice this rock it was necessary to blast it. The method of making the blast holes in the rock was novel, as the holes were bored to a sufficient depth for blasting with the giant. The blasting was done with dynamite.

The method adopted for making the embankment was as follows. Two flumes were built on the edges of the dam site and allowed to flow inward. In this way the gravel and sand were mixed, and the fine material had a tendency to collect at the middle of the dam, while the coarse formed a good protection to the outside of the dam. The embankment was made exceptionally wide, so that the capacity of the reservoir could be increased at a later date. The resulting dam was well packed, and the natural deposition of the fine material in the center, and coarser stuff on the outside only required a slight riprapping on the upper slope to complete an economic and sufficient dam. The embankment contained 7,600 cu. yds.

Work was continued about 15½ hrs. each day and the job was finished in 80 days with 5 to 7 men working with one team. Thus about 31,620,000 gals. of water were pumped, equal to about 156,000 cu. yds. of water, to excavate and transport 7,600 cu. yds. The volume of material moved was about 5 per cent of the volume of the water. For each 4,175 gals. of water pumped 1 cu. yd of earth and rock was excavated and put into place. For each kilowatt of power consumed about 2,100 gals. of water was pumped. In addition 3,200 lbs. of dynamite was used in blasting.

The foreman was paid $3.00 and the laborers $2.25 per day. Electrical power was paid for at the rate of $60 per H. P. per year, and 40 per cent dynamite cost 13 cts. per lb. Teams are rated at $5.00 per day.

The total cost of the work, exclusive of general expense and any charge for plant was as follows:

Foreman	$ 240.00
Laborers	10,080.00
Team	400.00
Power	325.60
Dynamite	416.00
Incidentals	138.40
Total	$2,600.00

The cost per cu. yd. was as follows:

Foreman	$0.031
Laborers	0.142
Team	0.052
Power	0.042
Dynamite	0.055
Incidentals	0.020
Total	$0.342

To have done this work with scrapers would have meant that with the materials used a power embankment for holding water would have resulted and the porphyry would have quickly ruined the pans of the scraper.

Roads and Streets Section

Note: This Section is devoted to methods and costs of road and street construction. It will cover road building in all its details, the construction of pavements, sidewalks and gutters, the testing and use of paving materials and the machinery and tools used in road building and paving.

Examination of Tars for Use on Roads.

At the recent International Road Congress at Paris, France, one of the questions upon which was concentrated the most acute discussion and which brought out the sharpest diversities of opinion, was the use of coal tar in connection with the surfacing of roads in order to prevent wear and suppress dust. The congress finally adopted a resolution approving the use of tar when properly laid under favorable conditions. In our issue of Oct. 14, 1908, we published an article on the use of tars as dust preventives, giving methods of analysis and tentative specifications for their use. The matter was taken from a bulletin of the U. S. Office of Public Roads, and may be assumed to be the present practice in the United States. In England, considerable advance has been made in the treatment of roads with tars, and in a recent issue of The Surveyor, of London, England, Clayton Beadle and Henry P. Stevens describe some of the methods employed for the examination of tars for use on roads. We have reprinted the article as follows:

The custom of applying tar to the surface of roads for the abatement of the dust nuisance has become so general that an inquiry as to the best sorts of tar for the purpose should lead to results of considerable value. The word "tar" for the purpose we have in view comprises not only a number of grades of coal tars having qualities rendering them more or less suitable for application to road surfaces, but also materials from totally different sources and of different chemical composition. There is in the first place the crude coal tar, which is a by-product in the manufacture of coal gas; enormous quantities of this are produced yearly in this country. In the London district alone about 4,000,000 tons of coal are destructively distilled annually for the purpose of making coal gas, and yield, say, about 40,000,000 gallons of tar. A very large proportion of this is worked up for the manufacture of a variety of chemicals, including carbolic acid, solvent benzine, the coal-tar dyes, and a number of pharmaceutical preparations, in addition to which there are a number of applications for the crude tar, including its use as an antiseptic, for the manufacture of lampblack for treating timber and for tarring felt. Its use for tarring roads is quite a recent application, and seeing that the quality required would be very considerable, even if it became the custom to make use of it for main roads only, it is worth noting that there is a very considerable supply to draw upon.

Crude coal tar is an oily liquor heavier than water, the specific gravity lying as a rule betwen 1·1 and 1·2. The composition of the tar will depend upon the quality of the coal from which it is prepared, and the temperature at which it is distilled, and therefore crude tars from different districts may be expected to differ in composition and consequently in suitability for application to roads.

There also passes over with the tar in the process of distillation a quantity of finely divided carbon. This carbon collects with the tar, so that it is always found in the latter. The proportion of this constituent is of some importance in respect to the suitability of the tar for our purpose, as will be seen later. Similar tars are also obtained from blast furnaces, coke ovens, etc. In addition to the crude tars we have freed, refined or prepared tars, which are obtained from the crude tars by a preliminary distillation treatment. The price of these latter is not necessarily greater than the crude tar, as certain of the constituents removed in this preliminary treatment have a higher commercial value than the remainder.

Coal tar collects in the gas works in a long, shallow, semi-circular trough, termed the hydraulic main, and with it there condenses a considerable amount of watery liquor containing ammonia and other substances. The crude tar is always contaminated with some of this liquor, which is separated as completely as possible before subjecting the tar to distillation. It is obvious that this distillation process will free the tar from the finely-divided carbon which will remain behind in the still, the higher boiling constituents of the tar will also be found in the residue in the still, so that the refined tar prepared by this distillation process consists of certain ingredients only of the original crude tar. It is more fluid, its density is lower, and it is free from insoluble matter, points which render it altogether more suited for tarring roads than the original crude substances.

In addition to coal tars there are oil-gas tars which are obtained from certain petroleum residues and finally, special compositions of unknown origin, but usually one of the above which have been placed on the market for the purpose of road tarring.

In selecting a suitable tar, choice should be made of one (*a*) which is capable of rapidly penetrating the road surface (*b*) which binds firmly together the top layer of road surface down to a depth of, say 3 in or 4 in, and (c) which dries quickly so that the road can be used for traffic soon, if not immediately after the application of the tar without "picking up" and sticking to the wheels of vehicles passing over it

OUTLINE OF EXPERIMENTAL WORK

In making a study of a number of different tars on the market, the foregoing points have been borne in mind, and our experiments have been conducted on the following lines with a view to determining the relative advantages of the different grades as found on the market.

(1) The tars were examined to see if they contained any considerable percentage of ammoniacal liquor. This later is formed at the same time as the tar and collects in the hydraulic main of the gas works, and consequently all crude tars will contain a certain proportion of this liquor. There is no reason to suppose that the ammoniacal liquor should have a very detrimental effect on tar when used for road laying, but a strong and disagreeable odor would be given off when the tar is heated, and even at ordinary temperatures the tar, when spread on a surface, gives off ammoniacal compounds, and possesses a strong, although not necessarily disagreeable, smell.

(2) The rate at which a thin layer of tar dries when exposed to the air was determined. Experiments were made at ordinary temperatures (50 degrees to 60 degrees Fahr.), and what may be described as summer temperatures, say, 80 degrees to 90 degrees Fahr The surface of the road in summer sunlight would probably often exceed this latter figure. The loss of weight due to volatile constituents was also determined, and the condition and consistency of the dried surface noted.

(3) The rate of drying of the tar when mixed with sand was determined Equal quantities of fine silver-sand were weighed out into metal trays and equal quantities of the tars were poured on to the sand, the rate at which the tar penetrated the sand was noted, and also the rate at which the mass of sand and tar dried and the consistency of the dried residue.

(4) The rate at which the hot tars might be expected to penetrate the road surface. This of course might be got at by determining the viscosity of the tars in one of the usual forms of apparatus designed for this purpose, such as a vessel of a certain capacity provided at the bottom with an orifice of standard dimensions the time taken for the material to flow out through the orifice being a measure of the viscosity. Crude coal tar, however, would be very likely to block the small orifice owing to the finely divided carbon in suspension, and we consider the following method we have adopted more practical as more closely resembling the conditions in which the tar is to be used. We determined the capacity of the tar for penetrating the road surface by pouring an equal quantity of each tar on to a porous earthenware slab The time taken for the "wetness" to disappear from the surface was noted, and any portion of the tar which remained unabsorbed on the surface was scraped off and weighed, so that an estimate could be made relatively as to what proportion would remain on the surface of the road, and what proportion would penetrate beneath the surface

MATERIALS EXAMINED.

The samples of tars included in this series of experiments may be grouped in the following classes

Crude gas tars	1, 2, 3 and 4
Blast furnace tar	5.
Freed, refined or prepared tars	6, 7, 8 and 9
Oil gas tar	10.
Special composition for dust laying	11.

Under crude gas tars are included gas tars which have apparently undergone no purification treatment; the blast furnace tar was a similar untreated tar; the freed, refined or prepared tars were gas tars which had probably been subjected to a single distillation process; the oil-gas tar was, we were given to understand, a petroleum residue, and therefore different altogether in composition from the foregoing. Finally, the special composition for dust laying was not examined chemically with a view to identifying its composition.

TESTS AND RESULTS OBTAINED.

We will now proceed to describe the difference in behavior of these various tars, when examined under the conditions already specified.

1. As was expected, the crude gas tars, particularly (1), (2) and (4), contained a considerable quantity of ammoniacal gas liquor mixed with the tar, other samples, particularly (3), (6) and (8), gave off a small amount of alkaline vapor on heating The presence of much ammoniacal gas liquor mixed with the tar might prove troublesome on account of the strong odor given off when the tars are heated, but otherwise we do not think they should be rejected on this account The crude tars however, have other disadvantages which will appear later

2. When dried down in a thin layer at a temperature of 80 to 90 degrees Fahr., the following figures show the percentage loss of weight with the different tars

(1)	20.5
(2)	27.0
(3)	20.1
(4)	17.6
(5)	7.8
(6) .	25.0
(7)	26.1
(8)	15.1
(9)	11.1
(10) .	26.2
(11)	21.9

In the case of the crude tars (1), (2) and (3), the loss of weight is probably largely due to moisture and ammoniacal vapor. With regard to the rate of drying and the consistency of the surface after drying these are difficult to express numerically, but the following short remarks may give some information on these points

(1) Surface no longer sticky but readily takes the impression of the finger

(2) A little stiffer than No. 1

(3) Inclined to be sticky and to adhere to the finger when pressed

(4) Surface rather sticky and adheres to the finger, inclined to be still fluid

(5) Surface inclined to be sticky but not fluid.

(6) Surface no longer sticky, but stiff and dry

(7) Sticky on surface and rather fluid

(8) Surface sticky but not fluid

(9) Surface slightly sticky and inclined to be fluid.

(10) Very fluid and shows little signs of drying

(11) Surface slightly sticky and inclined to be fluid.

3. When poured on sand the tar is absorbed at different rates, according to its consistency. After drying for twenty-four hours the mass may be soft or firm. The list below gives some details on these two points:

(1) Absorption slow, but mass after drying very hard and stiff.

(2) Absorption fairly rapid and mass fairly stiff

(3) Absroption slow, but mass fairly stiff

(4) Absorption very slow, but mass fairly stiff

(5) Absorption very slow indeed, even on long standing the tar did not seem to have been thoroughly absorbed by the sand.

(6) Absorption very rapid and mass moderately stiff

(7) Absorption very rapid and mass rather soft

(8) Absorption rather slow and mass fairly stiff

(9) Absorption rather rapid and mass rather stiff

(10) Absorption immediate but mass very soft

(11) Absorption fairly rapid and mass moderately stiff

4. In these experiments equal quantities of the tars were poured upon porous porcelain slabs the results obtained are given in three columns Column 1 gives the time required for the wet appearance of the tar to go off from the porous surface, column 2 gives the percentage of tar remaining on the porous surface, and column 3 gives the percentage of tar which

has penetrated into the porous tile. This latter figure may be described as percentage penetration:

	Time.	Residue.	Penetration.
(1)	1 hr. 15 min.	53%	47%
(2)	25 min.	22%	78%
(3)	1 hr. 12 min.	8%	92%
(4)	1 hr. 15 min.	47%	53%
(5)	Over 2 hrs.	37%	63%
(6)	25 min.	21%	79%
(7)	15 min.	—	100%
(8)	38 min.	35%	65%
(9)	15—20 min.	33%	67%
(10)	5 min.	—	100%
(11)	4 min.	29%	71%

The material left on the surface and not absorbed by the tile is of a sticky nature, and consists apparently to a large extent of finely-divided carbon. This finely-divided carbon is contained in all crude tar, and therefore, as might be expected, the samples of crude tar and the blast-furnace tar leave a considerable amount of material on the surface. No. 3 is an exception, the amount of residue being exceptionally small for a crude tar.

It may be mentioned that samples (2) and (6) are from the same source, sample (6) was therefore probably prepared from sample (2), and it is worthy of note that the crude tar (sample 2) penetrates practically as readily as the sample of prepared tar (No. 6) obtained from it. Not only are the times required for absorption of the tars practically the same, but the residues left on the porous tiles were about the same in amount. The large proportion of residue left by (6), (8) and (9) inclines one to doubt whether these samples were really prepared by a distillation process at all. The rapidity with which they penetrate distinguishes them from the crude tars, in which the penetration is usually slow.

We now have the material from which important conclusions can be drawn as to the suitability of any particular tar for our purpose.

A sample of crude tar, such as No. 1, which would slowly penetrate the surface of the road, might be expected to leave half its weight as a sticky deposit on the surface, and it is obviously not the best adapted for tarring roads. Sample (4) is almost as bad, samples (2) and (3) are better adapted, particularly sample (2), on account of its rapid penetration, while the quantity of residue left on the surface is not excessive. It also shows good drying powers and yields a fairly stiff mass with sand.

Of the four samples of crude tars, we should certainly give preference to No. 2. It is really surprising that crude coal tars should show such differences in behavior under like conditions.

No doubt, in most cases where the crude tar is employed on the roads the local gas works furnishes what is required, and the local tar, even if relatively unsuitable for the purpose, would be given the preference on the score of convenience and economy. On the other hand, where more than one source of supply is fairly readily available, it would appear to be well worth while making a trial of as many as can be obtained at a moderate cost in order to ascertain the best adapted for the purpose.

The sample of blast-furnace tar is obviously wholly unsuitable on account of its lack of penetrating power and large proportion of residue unabsorbed by a porous medium.

We now come to the group of refined or prepared tars, Nos. 6 to 9. Their penetrative power is much greater than any of the previous samples except No. 2. No. 7 would appear to be the best both as regards penetration and residue left on the road surface, which latter is practically *nil*. It, however, does not dry well, and leaves a rather soft mass when mixed with sand. No. 6 is decidedly preferable to No. 7 in these latter respects, its penetration is fairly high and the residue left on the surface comparatively small. Nos. 8 and 9 resemble No. 6, but hardly come out so well. Sample (10), which is a petroleum residue product, somewhat resembles No. 7, but its power of penetration is even greater. On the other hand, it remains fluid, and shows no sign whatever of drying up or hardening. It would appear, therefore, that it would possess no power to bind together the road surface, although on the other hand, it might prove a very efficient dust layer. Similarly, the special composition No. 11 does not dry readily, although much superior to No. 10 in this respect. It has great penetrative power, but contains a fairly large percentage of material which might be expected to remain on the surface of the road.

The road expert after a few years of experience on tarred roads will better be able to form an opinion upon the requirements of tar for road work. Thus it does not follow that a tar that completely penetrates, leaving nothing on the surface, is the best for the purpose. A certain amount of surface coating is desirable, in fact, is probably indispensable, if sand is to be spread upon the surface after the tar is applied. On the other hand a proper amount of penetration is of equal importance, as the tar is to be a binding material as well as a dust layer. No doubt differences of opinion would arise on these and other points in different localities. The kind of road, as well as the amount and nature of the traffic, would largely determine the mode of applying the tar, as well as the amount of tar needed, but nevertheless the nature of the tar can be ascertained by applying tests as above recorded from which the surveyor can form his opinion when his choice lies between a number of samples.

In drawing any conclusion from penetration tests made in the laboratory it must not be forgotten that the amount of moisture in a road would make all the difference to the amount of penetration; therefore penetration in any road will vary unless the surface is uniformly dry, as well as uniform in other respects. The penetrability of tar should be great enough to insure sufficient penetration at all points and under all conditions, otherwise a marked unevenness may result.

There is a further important point which should engage the attention of the chemist—namely, the difficulty arising from the poisoning of streams and other watercourses when the surface water from freshly tarred roads flows into them. The constituents removed by water from the fresh tar possess antiseptic qualities, and in consequence are of actual service in flushing of drains, etc., but they are decidedly harmful to fish life, and may do much harm to the riparian owner.

Some tars contain large quantities of these harmful substances, whereas others are comparatively free from them. In such districts where the surface water is likely to reach streams, etc., where harm may result, a tar free from these harmful substances should be made use of.

If tar comes into very extensive use for the surface of roads it may be found necessary to look for fresh supplies. The supplies from gas works are somewhat elastic, because when tar is very cheap a great amount is used for firing the retorts, but apart from this source of supply, we have that obtainable from blast furnaces, coking ovens, producer gas, Mond gas plant, etc., so that no scarcity need be anticipated on the score of its use for road purposes.

A recent consular report states that experiments were made at Genoa, Italy, some few months ago, with a view of testing the adaptability of re-enforced concrete in the construction of barges or lighters for use in that Italian port in the handling of coal and other merchandise. Contrary to what was expected, states the report, these lighters were not a success. It was found that they did not possess the necessary elasticity to resist the bumping and squeezing to which they were often subjected when alongside or between steamers engaged in discharging cargo. After a short trial, during which it was found that the concrete was badly broken or cracked, because of this non-elasticity, their use was discontinued.

Governor Prouty of Vermont has approved the legislative bill for the formation of a state forestry commission. The commission will consist of five members, including the governor and the director of the state experiment station. The commissioners are to serve without pay, but the bill provides for the employment of a forester at a salary of not over $2,500 per year.

Unclassified and General Articles

Note: This section is devoted to methods and cost articles on construction work not properly coming under any of the preceding classifications.

Water-Works Valuation and Fair Rates in the Light of the Maine Supreme Court Decisions in the Waterville and Brunswick Cases.

(Concluded from p. 15, Jan. 6 issue.)

SOME SIGNIFICANT RULINGS UPON THE ADMISSIBILITY OF EVIDENCE BY THE APPRAISERS IN THE PORTLAND (MAINE) WATER-WORKS VALUATION CASE.

In the course of the trial in the Portland water-works valuation suit, some important questions of general interest in water-works valuation were ruled upon by the tribunal, and in view, not only of the magnitude of the case—which covered the valuation of the plants of the Portland Water Company, the Standish Water and Supply Company, the Gorham Water Company, the Foreside Water Company, and the Presumpscot Water Power Company, and amounted to nearly $1,000,000—but also of the excellence of this tribunal (which was made up of Judge Albert R. Savage, of the Supreme Court of Maine, the writer of the Waterville and Brunswick opinions and Chairman of this Board of Appraisers; Judge Frederick A. Powers, recently retired from the Supreme Bench of Maine, who had previously sat as Chairman in the Waterville and in the Livermore Falls cases, and had participated in the Waterville and Brunswick decisions; and United States Marshal Henry W. Mayo, who had himself previously served upon water-works appraisal boards), it may be of interest to quote the more important of these rulings, which may be assumed to be indicative at least of the probable attitude of the Supreme Court of Maine upon the points in question.

These rulings covered the question of admissibility of evidence upon the following issues:

1.—Expert testimony on "going concern" value, "franchise" value, and total value of works. Excluded, except upon purely technical questions involved.

2.—Need and cost of reinforcement of distribution pipe system. Admitted.

3.—Selling prices of water company stock as tending to show value. Excluded.

4.—Depreciation, as based upon or measured by the substitution of another equally efficient or different structure to do the work of the existing structure. Excluded, except as bearing upon relative efficiency of the plant.

The trial of the last three Maine water works valuation suits, which were all conducted on behalf of the several municipalities by the Hon. Herbert M. Heath, of Augusta, and were unique in American annals of such cases, in that he argued successfully against the admission of any testimony upon the total value of the property of the water company by the experts or engineers, holding that in valuing the property as a whole the expert was usurping the functions of the tribunal, that expert testimony was admissible only in so far as it dealt with facts or matters of opinion beyond the ability of the layman to grasp without expert assistance; and that valuation implied a thorough knowledge of value standards, a knowledge of the law as well as of engineering principles or theories, since valuation was a mixed question of fact, judgment, and the law, therefore must be made always with a full knowledge of the law upon such cases. The appraisers in all these cases (Kittery, Livermore Falls, and Portland) sustained this contention, as appears in the first ruling, quoted later. These rulings are the only examples of such a ruling in water-works valuation in America that have thus far come to the attention of the writer. The experts only testified as to engineering facts, principles, and costs, and not as to property values or the elements thereof. In each case, however, the engineers assisted counsel in the preparation of the necessary tables and data upon valuation, which thus went into the arguments, instead of being presented in testimony. The plan here followed would appear to have some advantages, and it seems likely to be tried elsewhere unless exception should be taken to the ruling, be carried up to the full bench, and there be upset on the broad ground of expediency. Abstracts of the rulings follow.

[The abstracts occupy 9 pages and are omitted.—EDITOR.]

EFFORT TO ELIMINATE, IN WATER-WORKS VALUATION, THE VALUE OF FRANCHISE AND OTHER RIGHTS ACQUIRED BY LEGISLATIVE GRANT

With the growing recognition of the rights of the public, and the obligations, as well as the rights of public service corporations, has come the endeavor on the part of the public to retain for itself, in granting authority to operate quasi-municipal corporations, any values that may develop directly from these grants.

Thus Massachusetts has sought to eliminate the element of franchise value in water works valuation by express provision in the Charter or Incorporation Act of the Companies, covering this point. Hence in the Haverhill, Newburyport, and Gloucester cases (as in the Kansas City case), franchise considerations were eliminated and the works were appraised upon the basis of their value to the purchaser rather than to the seller, as is provided for in the Maine rulings.

A somewhat similar situation is found in England as outlined in the report of the London County Council upon the "Water Supply of London, and a Bibliography of the Principal Reports and Papers on the Subject, together with a Special Report by the Comptroller of the Council on the Financial Aspects of the Purchase."

ENGLISH PRECEDENT FOR RESTRICTING THE VALUATION OF THE FRANCHISE AND OTHER RIGHTS ACQUIRED BY GRANT

[The 2½ pages quoting various acts are omitted.—EDITORS.]

The valuation of the London companies appears to have been based upon a consideration of:

1.—The dividend being earned by them upon the capital stock of the company which is restricted rigidly to actual cash investment, allowance being made for a 10% dividend from the time of incorporation of the company, provided the income of the company justified this return.

2.—The probable continuity of and growth in future income.

3.—The character of the plant and of the service furnished and the probable needs of the future.

4.—The effect of the sinking fund, sterilization, and other similar clauses under which the companies were operating.

5.—A 1½% allowance for cost of reinvestment and other costs.

As stated by the Comptroller, the company's works were valued upon a basis of their value to the vender, rather than to the purchaser, upon the "perpetual existence of the companies, and apparently upon the adoption of an average of the past ten years as a starting point for their valuation."

The Comptroller further observes that he doubts "whether sufficient weight had been attached in the recent arbitrations to the large expenditure on capital account which will be required at no distant date."

It is also interesting to note that, as in the recent Maine cases, "the Court ruled that the question of the value of the undertaking was a matter for the Court, and his evidence (the witness's) was therefore limited to facts concerning the condition of the company's works and plant."

It is impossible, within the limits of this paper, to discuss in detail the awards in the London cases, but those particularly interested in this subject will find the report of the London County Council, referred to, well worth perusal.

SOME RECENT AWARDS IN NEW ENGLAND IN WATER-WORKS VALUATION CASES

Table I, though more or less fragmentary, may be of casual interest to the reader, particularly if he is familiar with the works. Without a fair knowledge of local conditions, it is not safe to generalize from figures of this kind. Particular attention is called to the fact that no deduction has been made from the net annual income to cover depreciation or interest upon fixed charges, and similarly in determining the ratio of net income to award, this ratio is determined from the approximate net annual income exclusive of depreciation and interest charges as shown.

Notes to Table 4.—

(1) Estimated from Census.

(2) Charles F. Parks' estimate of future income, including estimated hydrant rental.

(3) Normal for 1902, estimate of expert for company.

TABLE IV.—SOME RECENT AWARDS IN NEW ENGLAND IN WATER-WORKS VALUATION CASES.

Date of of taking.	Name.	Year of original construction.	Population.	Estimated actual cost.	Reproduction cost. Approximate.	Depreciation to date.	Approximate net annual income, exclusive of depreciation and interest charges.	Award.	Award per capita.	Ratio of award to reproduction cost.	Ratio of net annual income to award without allowance for depreciation.
June 12, 1887	Braintree, Mass.	....	4,300 (1)	....	....	....	$10,750 (2)	$ 159,610.44	$37.12	....	6.7
Oct., 1895	Gloucester, Mass.	......	28,211	....	....	....	....	600,500.00	21 29	....	....
1898	Fulton & Oswego Falls, N. Y.	......	....	....	....	....	11,340	172,500.00	....	......	6.6
1901	Newmarket, N. H.	....	1,800	....	....	....	5,100	83,000.00	46.11	.....	6 2
1902	Dover and Foxcroft., Me.	.....	3,600 (1)	....	....	....	7,057 (3) 7,500 (4)	135,659.31	37.70		5.2 5.5
1903	Gardner, Mass	.....	11,700 (1)	....	$165,000.00 (5)	....	13,700 (6) 20,000	274,000.00	23.42	1.66	5 0 7.3
July 1, 1903	Gardiner, Me.	....	7,380 (1)	....	132,000 00 (7)	$35,854 (7)	15,556	245,000.00	33.20	1 85	6.4
July, 1903	Waterville, Me.	1887	17,600	$250,000	368,546.00 (8) 288,776 00 (7)	32,400 61,800	32,700 (9) 34,580	.... 503,475.37	.... 28.58	1 37 1.74	6.5 6 9
Jan. 1, 1904	Brunswick, Me.	....	6,930	....	130,455(24)(7)	18,529 (7)	15,000(25)	196,162.09	28.31	1 24(24)	7 7
1904	Augusta, Me.	.	12,100 (1)	300,000	....	....	31,000	427,135.20	35.29	1.5	7 3
Jan. 1, 1905	Athol, Mass.	1877 (?)	7,196	....	206,386 00	39,253 (7)	17,000	316,500 00	43.99	1.53	5 4
1905	Amesbury, Mass.	..	8,840	....	205,573 00	46,521	13,000	265,000 00	29.98	1 29	4.9
Dec., 1906	No. Conway, N. H.	1884	1,700(12)	..	35,300.00(13)	8,100(14)	3,700	62,000 00	36 46	1 76	6 0
1906	Ithaca, N. Y.	1872	18,000(15)	...	551,575 00(16) 322,793 00(17)	....	40,750	658,000 00	36.56	1 19 2.04	6 2
Jan. 1, 1907	Derry, N. H.	1891	4,500	....	80,878.06	12,750	7,399	125,500 00	27,89	1.55	5.9
July, 1907	Kittery, Me.	1902	3,000(18)	81,000	102,510 25	2,200	10,786(19)	163,869.00	54.70(18)	1.60	6.6
Oct., 1907	Livermore Falls, Me.	1899	3,142	66,000	85,394.36	3,455(20) 1,800	9,364	117,698 00	37 46	1 38	8 0
Jan. 1, 1908	Portland, Me.:										
	Portland Water Co.	1868 *et seq.*	45,600	1,425,500	1,525,476.00(21) 1,685,696.00(22)	656,694(23) 84,609 (8)	 147,055	....	....	..	....
	Gorham Water Co.	1895	2,500	....	67,000.00(21) 71,960 00(22)	5,856(23) 4,504 (8)	 2,291	2,539,235 00	51 20	1.53	5.9
	Foreside Water Co.	1906	1,500	58,300	70,400.00(21) 71,920 00(22)	649(22) 212 (8)	 0	....	....	....	....
	Standish Water and Constr. Co.	1886 and earlier.	28,600	....	931,500 00(21) 1,024,120 00(22)	233,394(23) 35,014 (8)	64,200	1,313,798.00	45.94	1.41	4.9
	Average of column								$36 40*	1.54	†6 2
	Average based upon totals								37.52	1.50	†5 9

*Excluding Fulton and Oswego Falls. †Excluding Gloucester.

(4) Anticipated for 1903, estimate of expert for company.

(5) Finding of Commission after deducting depreciation on value of physical plant, exclusive water rights, street franchises, and going concern value.

(6) Finding of Commission on fair net or divisible income.

(7) F. C. Coffin, expert for town.

(8) William Wheeler, expert for company.

(9) Estimated by Water District Engineers.

(12) Exclusive of large summer population.

(13) Agreed reproduction cost exclusive of engineering and contingencies $31,380. Amount given includes 12½ per cent.

(14) Town experts' estimate.

(15) Exclusive of 3,000 at University.

(16) Average of company's experts, after deducting depreciation.

(17) Average of city's experts after deducting depreciation.

(18) Bulk of water used at Navy Yard for manufacturing.

(19) $10,346 less depreciation.

(20) (?)

(21) Exclusive of service pipes, hydrant, and drinking fountains.

*(22) Inclusive of service pipes, hydrant, and drinking fountains.

(23) Exclusive services, etc., Water District experts' estimates.

(24) Agreed reproduction cost by engineers, $158,389.40.

(25) Average net revenue, 5½ years, $14,434.40.

WATER-WORKS VALUATION.

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*Ownership at issue, and probably vested in the water consumers.

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CONCLUSION.

It seems unnecessary to attempt a recapitulation of the matters discussed herein, as the length of this article has far exceeded intended limits, and as only comparatively few directly interested in water-works valuation and fair-rate cases will be likely to scan these lines. The paper was prompted by the desire to submit, for discussion, by members of this Society, the method outlined herein of applying, in water-works valuation, the vital principle or gauge of fair rates—"the-worth-of-the-service to the consumer," so admirably laid down by Judge Savage in the Brunswick decision destined to be much quoted, and to exercise a large influence in water-works valuation and rating cases in the future.

It is not suggested that the method discussed and illustrated herein is the only correct method, or the final criterion of value, or that it is the interpretation which the Supreme Court of Maine would put upon its own ruling. It furnishes, however, another standard for water-works valuation and for the determination of fair rates—perhaps a more tangible and rational one than some that have been used in the past.

As applied to works which have been seriously over-capitalized to cover up excessive earnings, it will bear heavily; to capital actually and prudently invested in the property, it will afford ample protection.

To old and outgrown works which, not content with dividing the real earnings of the company and failing to recognize and provide for the inevitable depreciation resulting from lapse of time, long service and other conditions, have actually divided up the plant in dividends, it will result in present loss to an over greedy corporation. To the prudent and well managed company and to new capital seeking opportunity for investment in public service works, it will give added safety and be attractive.

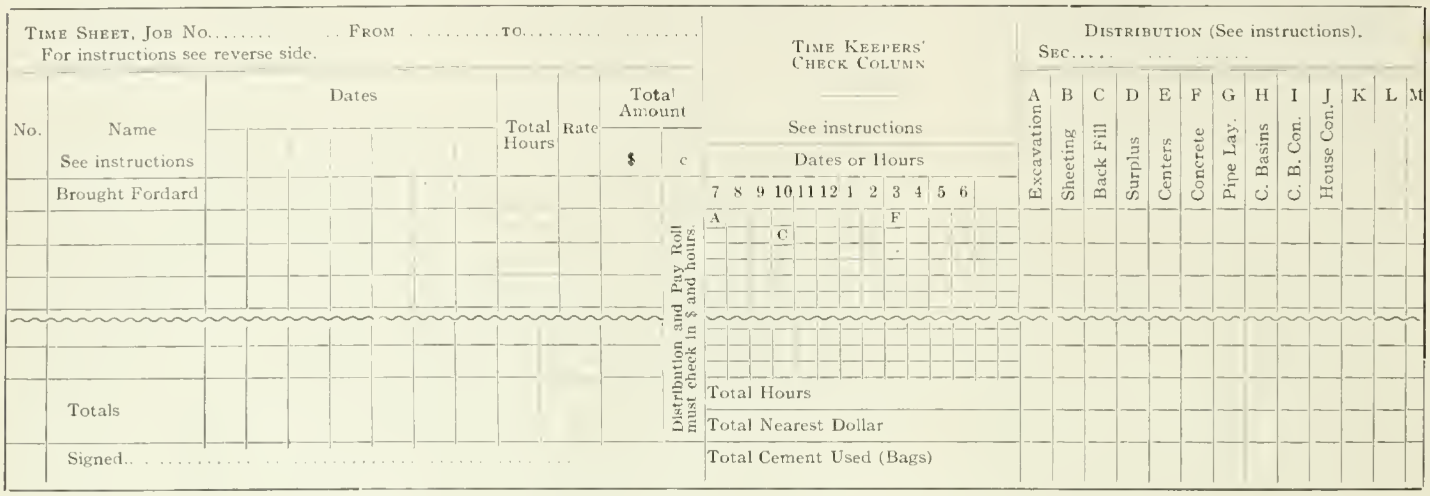
In conclusion, the writer desires to make grateful acknowledgment of his obligation to Messrs. Allen Hazen, William Wheeler, Harrison P. Eddy and Charles W. Sherman, members, Am. Soc. C. E., for friendly suggestions upon this paper, and to the Hon. Herbert M. Heath, of Augusta, Maine, Corporation Counsel, for permission to make use of his arguments in the Maine case cited.

During the past year 410.8 miles of public highway improvements in Minnesota were completed. The total cost of road work done under state aid was $213,960.

A System of Collecting Cost Data With Particular Reference to a Sewer Contract.

The system of collecting cost data herein explained is that used by the Moore-Mansfield Construction Company and the Mansfield Engineering Company, associated companies, maintaining an engineering designing and general contracting office at Indianapolis, Indiana. The character of the work done by them covers almost the entire field of engineering and architectural construction and it has been the effort of their Mr. Moore, who gives his time very largely to estimating and cost record department of the organizations, to prepare a system which may be used uniformly through their work and which may be used for the different character of the work done, with only minor changes and modifications, for each job.

The essential and fundamental feature of the system depends upon the form of the time sheet used (see Fig. 1, front view of time sheet, and Fig. 2, back view). The time sheet is folded when in use by the timekeeper and carried in a cover, making the same of book size, and practically the same form as the ordinary time book. On the left hand side of the front appears the time sheet in the usual form. This time sheet is arranged so that it may be used for a gang reporting time weekly, and is also used where the time sheet is turned in each day, in which latter case the lines under the column dates are ignored and the time placed in the total hour column. On the left hand side appears first the timekeepers check column. The instructions to the timekeeper on the back of the sheet (Fig. 2) are probably sufficiently clear, although it might be added that where the time sheet is used as a weekly report, as is generally the case, where the



TIME SHEET, JOB NO........ ..FROM ....TO......... ....
For instructions see reverse side.

No.	Name	Dates							Total Hours	Rate	Total Amount	
	See instructions										$	c
	Brought Fordard											
	Totals											
	Signed..											

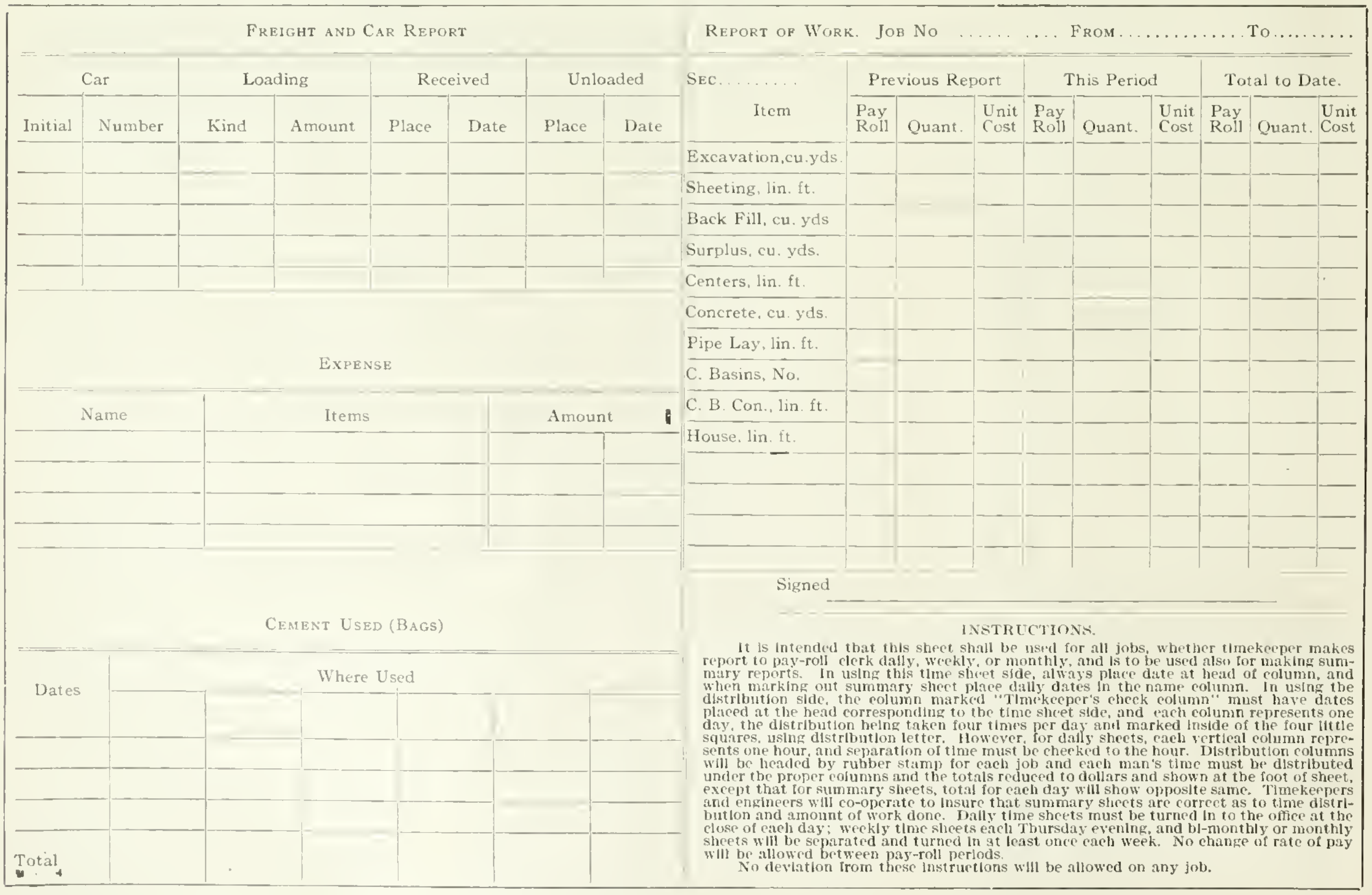
Distribution and Pay Roll must check in $ and hours.

TIME KEEPERS' CHECK COLUMN

DISTRIBUTION (See instructions).
SEC..... ... .

See instructions Dates or Hours	A Excavation	B Sheeting	C Back Fill	D Surplus	E Centers	F Concrete	G Pipe Lay.	H C. Basins	I C. B. Con.	J House Con.	K	L	M
7 8 9 10 11 12 1 2 3 4 5 6													
A F													
C													
Total Hours													
Total Nearest Dollar													
Total Cement Used (Bags)													

Fig. 1—Front View of Time Sheet—(Actual Size of Sheet Is 8½x10 Ins.)



FREIGHT AND CAR REPORT

Car		Loading		Received		Unloaded	
Initial	Number	Kind	Amount	Place	Date	Place	Date

EXPENSE

Name	Items	Amount

CEMENT USED (BAGS)

Dates	Where Used				
Total					

REPORT OF WORK. JOB NO .... FROM.............TO..........

Sec.........	Previous Report			This Period			Total to Date.		
Item	Pay Roll	Quant.	Unit Cost	Pay Roll	Quant.	Unit Cost	Pay Roll	Quant.	Unit Cost
Excavation, cu. yds.									
Sheeting, lin. ft.									
Back Fill, cu. yds									
Surplus, cu. yds.									
Centers, lin. ft.									
Concrete, cu. yds.									
Pipe Lay, lin. ft.									
C. Basins, No.									
C. B. Con., lin. ft.									
House, lin. ft.									

Signed

INSTRUCTIONS.

It is intended that this sheet shall be used for all jobs, whether timekeeper makes report to pay-roll clerk daily, weekly, or monthly, and is to be used also for making summary reports. In using this time sheet side, always place date at head of column, and when marking out summary sheet place daily dates in the name column. In using the distribution side, the column marked "Timekeeper's check column" must have dates placed at the head corresponding to the time sheet side, and each column represents one day, the distribution being taken four times per day and marked inside of the four little squares, using distribution letter. However, for daily sheets, each vertical column represents one hour, and separation of time must be checked to the hour. Distribution columns will be headed by rubber stamp for each job and each man's time must be distributed under the proper columns and the totals reduced to dollars and shown at the foot of sheet, except that for summary sheets, total for each day will show opposite same. Timekeepers and engineers will co-operate to insure that summary sheets are correct as to time distribution and amount of work done. Daily time sheets must be turned in to the office at the close of each day; weekly time sheets each Thursday evening, and bi-monthly or monthly sheets will be separated and turned in at least once each week. No change of rate of pay will be allowed between pay-roll periods.

No deviation from these instructions will be allowed on any job.

Fig. 2—Back View of Time Sheet.

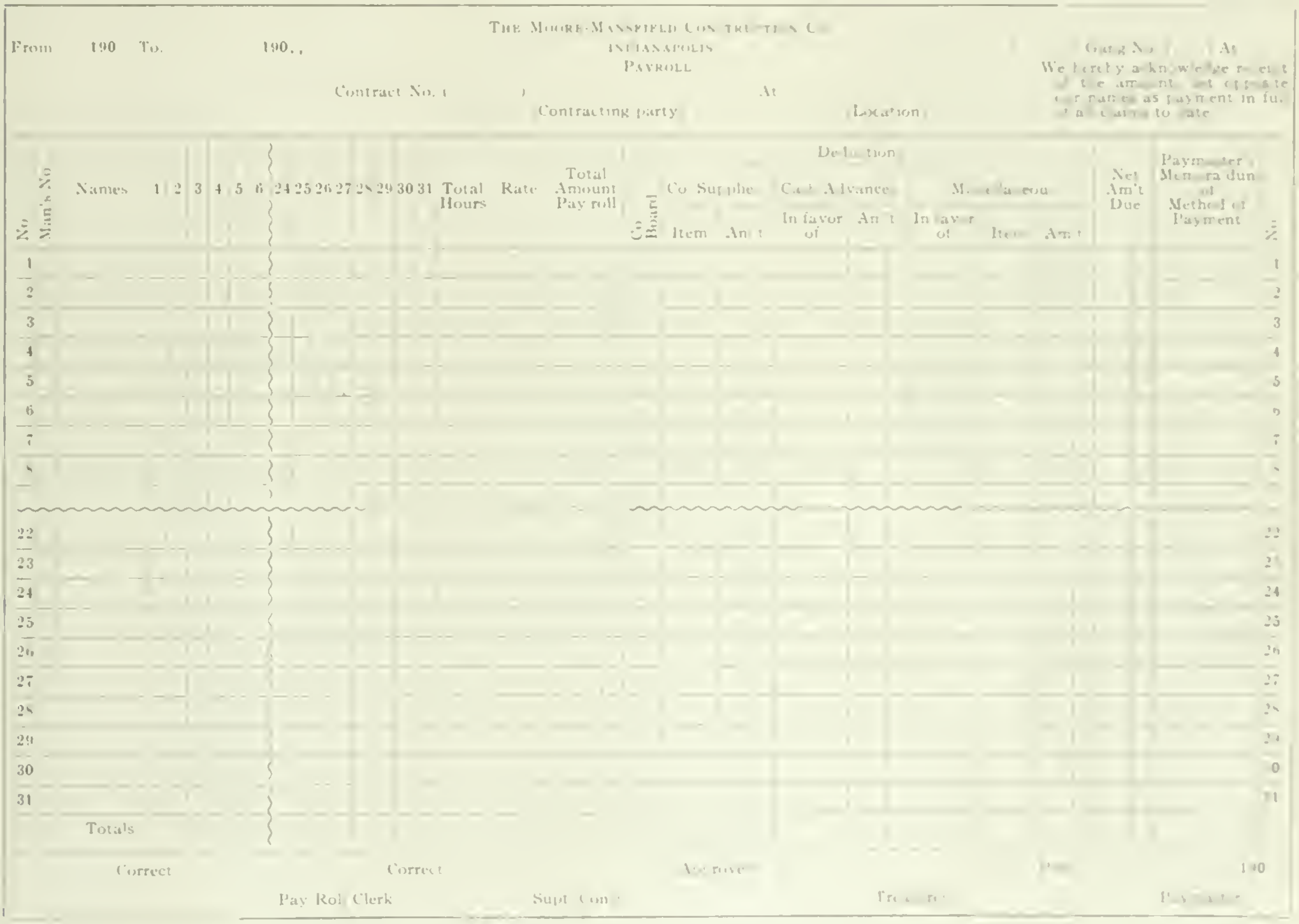
gang is small or where the work is unimportant, the time is checked and divided by means of the four squares under each date and opposite each name, each square thus representing one fourth of a day. In the case of the time sheet as illustrated, the distributions shown are for a sewer job and the particular distributions required are shown printed in by means of a rubber stamp. Each distribution thereby for this job shows a particular key letter although the same letter may not mean the same thing on any two jobs, but reference is made to the rubber stamp heading on each contract to determine the meaning of such letter.

In the case of the daily report of a job in the timekeeper's check column, each principal column under the "Dates" is counted as two hours or each single column is counted as one hour. Each small square opposite each name in such column indicates a thirty minutes check. By this means, automatically a man's time is checked by thirty minute intervals extending over a fourteen hour day. In using a checking system of this idea, it is not necessary to write the letter indicating the distribution in each square. Suppose that in the first square in the first column, a man is checked in at 7:00 as working on excavation, distribution A; no further letters or checks are made until the man changes the nature of his occupation which we will assume is done at 10:30, in which case a check is made in the bottom square under the ten hour column. Suppose, in this case, the man changes his work to distribution C, indicating back fill. This distribution is then carried until we assume that the man changes his time again at 3 P. M., which is indicated by the 9th column, and the letter E indicates that he has been placed upon the concrete gang, and we will assume that he so continues until the completion of the day. By even a casual observance of this man's time for the day, it is evident that he spent $3\frac{1}{2}$ hours upon back fill (taking an hour for noon), and assuming that the gang quit at 6:00 P. M. that he spent 3 hours upon concrete, making a ten hour day. This system has been found to work satisfactorily, either upon a weekly report basis or upon a daily report basis, and being used uniformly on all contracts, whatever the size of the job or the character of the work, the office work has been greatly simplified.

On the back of the time report are shown all of the matters ordinarily appearing in the life of any contract. A complete car report is made, also items of expense and amount of cement used. In the latter case, the opportunity is also given for the dates when the cement was used and where used. On the right hand side a complete report of the job is given. The manner in which this is done is apparent from the form given, but especial attention is called to the fact of the opportunity to check up current work with past work, and also to compare the total amount of work done to date. The items are printed in the same order by rubber stamps in the item column the same as they appear upon the reverse side of the sheet under the distribution. If the timekeeper is unable or incompetent to make a report of the amount of work accomplished, one of the supervising engineers cooperates with him to secure this information so that the report may be a complete one.

In the matter of the office work, complete pay rolls are prepared from the time sheet side and the cost of the work is posted in the cost record book. The cost record book, however, is not essential, but only as a matter of permanent record as the sheets themselves show total cost to date at all times of each item of work.

This form of timekeeping would be of value because of the system of uniformity alone, even if no regard were given to the other features mentioned, although the above companies using this report are satisfied that they are securing more valu



From 190 To. 190.,

THE MOORE-MANSFIELD CONSTRUCTION CO.
INDIANAPOLIS
PAYROLL

Gang No. At

We hereby acknowledge receipt of the amounts set opposite our names as payment in full of all claims to date

Contract No. ( ) At
Contracting party Location

																				Deductions									
No	Man's No	Names	1	2	3	4	5	6	24	25	26	27	28	29	30	31	Total Hours	Rate	Total Amount Pay roll	Co Board	Co Supplies		Cash Advances		Miscellaneous			Net Am't Due	Paymaster's Memoranda of Method of Payment	No
																					Item	Am't	In favor of	Am't	In favor of	Item	Am't			
1																														1
2																														2
3																														3
4																														4
5																														5
6																														6
7																														7
8																														8
22																														22
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25																														25
26																														26
27																														27
28																														28
29																														29
30																														30
31																														31
		Totals																												

Correct Correct Approved Paid 190
Pay Roll Clerk Supt Con Treasurer Paymaster

Fig. 3—Pay Roll Blank. (Actual Size of Sheet Is 11x17 Ins.)

able data by this form than they would have ever been able to do by previous forms used. The value of the uniform time sheet lies in the education of the timekeepers, resulting in a more efficient working force. Under the old system with individual time sheets, prepared especially for each job, the form of the time sheets were many and various, and, for this very reason, timekeepers presumed to incorporate their own ideas and make changes and innovations, resulting in a bunch of data that required hours and generally the personal attendance of the timekeepers to work out and reduce to any satisfactory understanding.

Passing from the time sheets, Fig. 1 and 2, pay rolls, Fig. 3, and the cost record book, the next feature of the system of information or cost data consists of progress charts. These, of course, will vary with any job according to the character of same and as they are used by nearly every large construction company, it will only be necessary to say that blue prints are prepared (generally blue line prints) upon which the timekeeper is able to color in the work completed each day of the week, marking dates thereon and turning such charts into the office. These progress blue prints thus form a permanent record of the progress of the work and also form the basis for the determination of the amount of work accomplished from time to time.

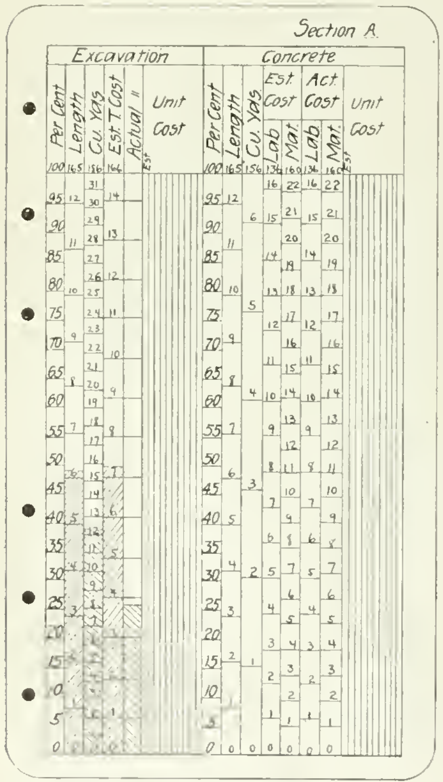

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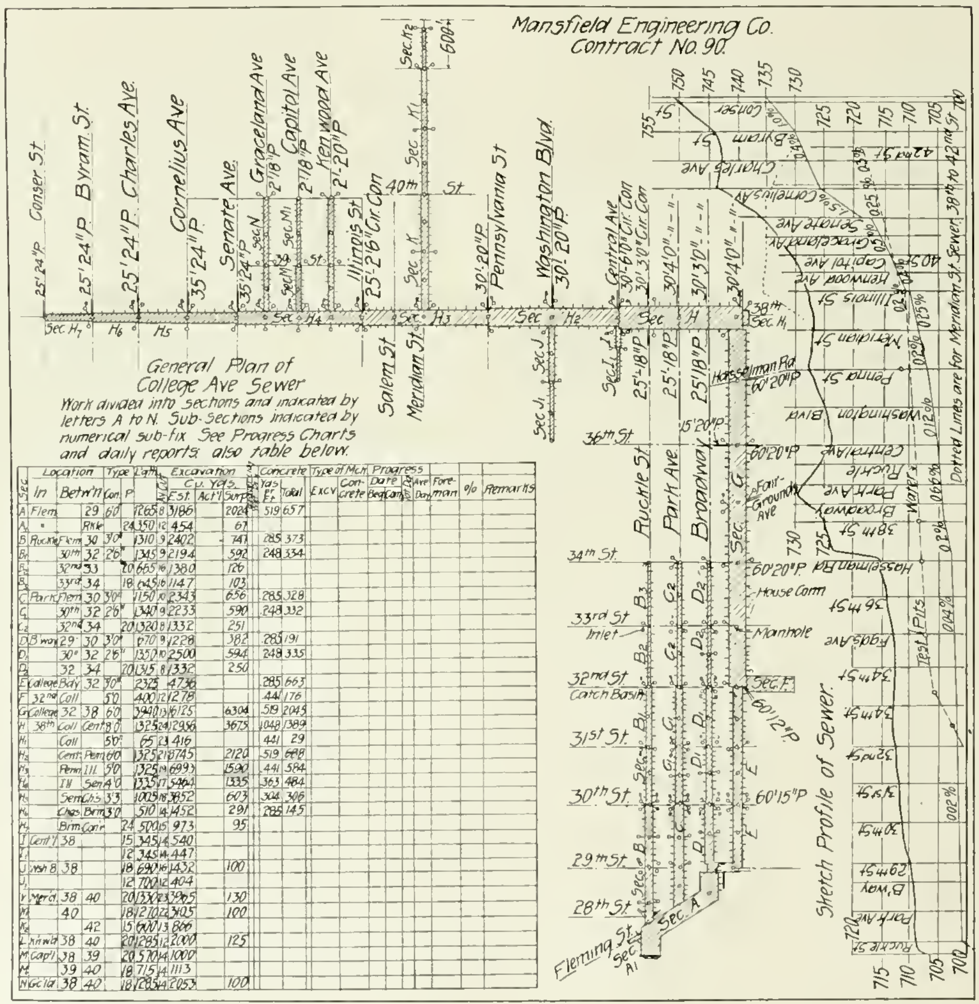
Fig. 4—Summary Progress Chart.

In connection with these progress charts, however, Mr. Moore has a unique summary progress chart upon which is carried forward and maintained a continuous record of the job, the information being obtained from the summary report on the back of the time sheet, and one of these summary progress charts is shown by Fig. 4. The essential idea of this summary progress chart is to have at all times a condensed, complete history of the work, not so much with reference to the detail unit cost of each item of work, but more especially with reference to a comparison between the estimated total cost and the actual total cost. This comparison allows an intelligent idea to be made of the portion of the work done, and indicates at once whether the actual cost is less than the estimated cost or exceeds same. The general form of this summary sheet is a standard, but of course will vary with each job as to the number of items making up the complete contract. Referring to Fig. 4, the chart illustrated is being used in connection with the sewer contract before mentioned, and a brief description will be given of the manner of the use of this chart. In this case, the sheet is ruled so as to cover two classes of work only; namely excavation and concrete. Under each one of these headings, the first column is a percentage column. In using the sheet, the length of the section is platted in the column marked length so that the complete length corresponds to the 100% line; the same is done with the estimated amount of cubic yards of material to be handled corresponding to such length. The estimated cost is then platted in dollars, the total, however, being made to correspond with the 50% line in the percentage column.



Eng-Contr.

Fig. 5—General Progress Blue Print.

Now, as the work proceeds, the actual cost is platted on the same scale as the estimated cost and shows at all times the relative proportion. No matter what the total length of the job or the total length to be handled, if the scale upon which same is platted is so made that the length corresponds with the 100% line, the general manager is able to tell, at all times, just where any one section of the job stands. For instance, the chart used for section A of the sewer, above mentioned, the 100% line equals in the length column 1,265 ft.= 3,186 yards=an estimated cost of $733.00, the latter point being opposite the 50% line. Now, for instance, on the first day of August, the actual feet of sewer constructed was colored in the length column as about 610 ft., immediately upon the percentage scale line, we see that this amounts to about 47%, and in the yardage column, this gives us 1,550 yards. Upon the estimated cost scale the amount to be expended for this amount of work was about $375.00. As an actual fact in the case mentioned, the actual cost to the date corresponded exactly to the amount of $175.00. At once, by casual observation, the general manager or superintendent is able to tell from very meagre information just where the job stands. Given the length, the cubic yards and estimated cost for the section may be read off the chart and the actual cost compared. If the record is made in number of cubic yards, and so platted, the corresponding length may be read off. In either case, the percentage of completed work may be compared with the percentage representing the actual cost and thus in turn compared with the percentage indicating the estimated cost.

The chart is also of great value on any section, especially where the work is of a character that it is continuous in its operation and continuous in the repetition of certain units of work in that the timekeepers or superintending engineers can read directly from the chart the data necessary to complete the report of work done on the reverse side of the time sheet.

In the particular chart shown, various lines were also drawn for unit cost so that at various times during the progress of the work, the fluctuating unit cost might be readily compared. This, however, is not essential, and, in fact, it is but seldom used.

In connection with the particular sewer job referred to above in as much as the sewer itself was of various sizes and to be built under varying conditions, the general progress blue print was made as shown by Fig. 5. Attention is called to the fact that each individual size of the sewer or change of conditions is indicated as a section and all reports are made upon the basis of such sections. Where the general character of the work is the same, and the work is to be handled by the same methods, a letter is used as indicating a general division and numerals added to indicate the sub-sections.

The costs of work, however, and amount of work accomplished are kept by sections and sub-sections, so that when the job is completed, the cost of each size sewer under the conditions met with, can be readily determined. In the particular case mentioned, the principal item being excavation, concrete, or pipe, the summary progress charts as just described are only kept on these particular items of work, although the miscellaneous items of work always appear and are carried forward upon the time sheets distribution and reports of work done.

The particular contract referred to above consists of about seven miles of main sewer, of which four miles is all concrete construction, three miles of pipe work, and there is also some four miles of miscellaneous pipe work, making in the aggregate eleven miles. The same system of cost recording is being used at this time to keep in tab with the construction of bridge work, the construction of a boulevard, embankment work, and also for the construction of several reinforced concrete buildings.

LETTERS TO THE EDITORS.

Cost of a Concrete Culvert.

Sirs: I find among my records the following cost of putting in concrete under unfavorable conditions. Perhaps it may prove of interest. Owing to inaccessible location and small amount of concrete (148 cu. yds.) no plant was installed and work was done entirely by hand. The structure was a double 3x3 culvert, with a 20-ft. manhole near the center, for the outlet to a small reservoir. The location—Big Horn Mountains, Wyo.—was 38 miles from the nearest railroad and the base of supplies, and was at a 5,300-ft. higher altitude, with a very bad wagon road connecting the two points. Prices and wages were as follows:

Hauling, town to site, per 100 lbs.	$ 1.00
Labor, per day, 10 hours	3.00
Team, wagon, driver, per day, 10 hrs	6.00
Fireman, per month	110.00
Lumber, per M at mill	14.00
Lumber hauling, per M	8.00
Cement, per bbl., delivered	7.00

The sand was hauled ½ mile. There was no gravel of any kind in the country, and the only stone procurable was a very hard granite boulder or spawl, which was collected with wagons and broken by sledges; hence high cost of same. The concrete was mixed 1-3-6, using 1 bbl. of cement per cubic yard. About 4,000 ft. B. M. were used for forms, the entire structure being encased inside and out. Mixing and placing concrete was done entirely by hand, with a small gang of inexperienced men. The excavation, 391 cu. yds., cost $363.50 = $0.93 per cu. yd., mostly pick and shovel work. The concrete work cost as follows:

	Total	Per cu. yd.
Lumber	$ 86.45	$ 0.60
Tools, tent, etc., 13% of cost chg'd	119.50	0.81
Carpenter work	121.13	0.82
Sand and stone	510.86	3.45
Cement, mixing and placing concrete	1,516.59	10.26
148 cu. yds. cost	$2,357.53	$15.93

There were $101.22 worth of tools on hand to credit to above cost. The work was done in 1905. Yours truly,

W. S. McFetridge,
M. Am. Soc. C. E.

Greenville, Pa., Dec. 11, 1908.

Deduction of Space Occupied by Street Railway Rails in Measuring Up Paving.

Sirs: A question has arisen between this firm as engineers and a firm of contractors, in reference to the proper measurement of the square yards in a street job on which there are four street car rails. Is it customary to deduct for the space occupied by the rails or not?

Dec. 9, 1908. Engineering Company.

[It is not customary to deduct for rails or for any opening under 1x1 ft. square unless specifically so stipulated in the specifications.—Editor.]

The Use of Cost Data for Measuring the Economy of Work.

Sirs: One sentence in your discussion on the Panama Canal work (Eng. Contr., Dec. 30, 1908, p. 443) attracted my attention, the one where you say: "The most important function (of cost data) is to furnish (the contractor) an accurate means of measuring the economy with which work is being done."

Some years ago while I had charge of the construction work of the Clinch Valley Division, Norfolk & Western R. R., the practice of one of the contracting firms, Messrs. McGarn & Stewart, was to keep the time account of every piece of work separate; this embraced gangs in charge of open excavations, tunnel excavations, bench and heading, foundation excavations of all kinds, masonry of all kinds, clearing and grubbing, in fact, all work incident and connected with railroad construction.

Supplies of all kinds—this included powder, dynamite and fuse—were charged to the gang using them, as was also blacksmith and other work.

This method required that the time of a man should be charged to the particular work he happened to be engaged upon, instead of the very usual way of keeping his time generally, no matter where he was engaged. A laborer might appear on the pay roll a dozen times, if he worked on that many jobs during the month, but this was not often the case.

At the end of the month the labor items, supply and other items would be tabulated, and then the exact cost of each piece of work ascertained. On a large railroad contract, of course, the main work is excavation, and there can be as many as a hundred or more gangs engaged on "cuts," oftentimes one at each end working towards the center. Usually the material is the same, that is, the character, be it earth, loose or solid rock, is the same.

On the work in question the resident engineers were permitted to give the contractor the returned quantities of each piece of work; this, in conjunction with the contract prices, gave the amount the contractor received for each separate piece of work from the railroad company.

A comparison of these amounts with the contractor's expenses would tell him at a glance which gang was making or losing money, and a little investigation would usually show where the fault lay.

Of course the contractor was not obliged to furnish his expenses to the engineers of the railroad company, but the latter could keep their own "force account" and thus arrive at a pretty close approximation of cost for their own in formation. In this connection it is interesting to state that the writer could closely approximate the forthcoming monthly estimates by merely multiplying the whole number of "days worked" during the month on any job by a constant or factor obtained by experience.

Yours truly,

EMILE LOW, M. Am. Soc. C. E.

606 Ashland Ave., Buffalo, N. Y., Jan. 1, 1909.

Amount of Materials Required for Cement Sidewalk Construction.

Sirs: I notice that you have a table (Engineering-Contracting, Nov. 4, 1908) showing quantities of cement and other materials required in cement sidewalk construction. Could you give us a similar table showing a 1-2-4 mixture for foundation; also a table on curb and gutter (6x14 ins. curb and 24 ins. gutter) combination, as shown in the accompanying sketch? Yours truly,

F. D. HARVEY.

Birmingham, Ala., Jan. 2, 1909.

(By using the tables of mortar and concrete quantities given in "Concrete Construction—Methods and Cost," by Gillette and Hill, or any other mortar and concrete tables that may be preferred, the data requested by our correspondent or similar data for any other mixture are readily computed by following the directions and using the constants given in our article of Nov. 4, 1908. We have, however, added the quantities for a 1-2-4 mixture to our original Table II, which now stands as shown. In computing this table, it must be remembered that a barrel of cement is assumed to measure 1.4 cu. ft., voids in sand to be 45 per cent, and voids in stone to be 40 per cent.

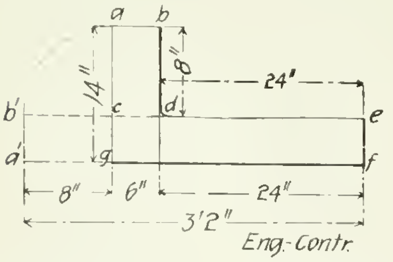


Diagram Section of Curb and Gutter.

Referring to the curb and gutter data requested by our correspondent, we have thought it somewhat useless to prepare similar tables, since the sections of such structures vary materially, hardly any two engineers using the same shape of section. Dimensions also vary. Considering the section shown by our correspondent, it is evident that a very close approximation of the quantities required can be obtained from the sidewalk table (Table II) given herewith. Assume the curb portion *a b c d* to be removed and placed at *a' b' c g*; we then have a slab 6 ins. thick and 38 ins. wide. This slab, like a cement walk, has a mortar finish and a concrete base and the quantities in it can be closely approximated from the table.—Editors.)

Personals.

Mr. J. W. Barnett has been elected City Engineer of Athens, Ga.

Mr. James C. Wonders, of Bellefontaine, O., has been reappointed State Highway Commissioner of Ohio.

The Texas Engineering Co. has opened offices at 706 Flat Iron Bldg., Fort Worth, Tex., and will engage in a general practice in civil and hydraulic engineering and contracting.

Mr. R. A. Thompson has resigned as Engineer of the Texas State Railroad Commission to become Chief Engineer of the Wichita Falls Lines. Mr. R. D. Parker will probably succeed him with the State Commission.

Mr. Chalres T. Main, well known through his extended practice as Mill Engineer and Architect, has been appointed by the Council of the American Society of Mechanical Engineers as a member of the National Conservation Commisison, with special reference to water powers.

Mr. C. S. Davis, Consulting Engineer, of Toledo, O., is to become General Manager of a large bridge and structural concern which is making arrangements to erect a plant at Massillon, O. Mr. Davis was Chief Engineer for the old Massillon Bridge Co., and later for its successor, the Toledo-Massillon Bridge Co.

The co-partnership of Connell, Sykes & Connell heretofore doing business at No. 90 West St., New York City, as Consulting Engineers, has by mutual consent been terminated by the retirement of Mr. H. W. Sykes. Messrs. H. W. Connell and H. F. Connell of the firm have formed a partnership under the firm name and style of Connell & Connell and will continue as formerly to a general business as Consulting Engineers at the same address.

Mr. Willard Guild, heretofore engineer in charge of construction on the Atchison, Topeka & Santa Fe Ry. double track work in Missouri, has been made Division Engineer of the Illinois Division of the above road with headquarters at Chillicothe, Ill., succeeding Mr. Charles Griggs, who has been transferred to Topeka, Kan., to take charge of the Eastern Division. Mr. Griggs succeeds Mr. George J. Graves, who has been transferred to Dodge City to take charge of the Central Grand Division.

D. D. Carothers, Chief Engineer of the Baltimore & Ohio R. R., died Jan. 1, at Baltimore, Md., after a short illness. Mr. Carothers was born in Ohio in 1860 and began his railway work in 1882 as a rodman on the Wheeling & Lake Erie R. R. In 1883 he became Assistant Engineer of that road and two years later became Chief Engineer of the Columbus & Cincinnati Midland R. R. He remained in this position until 1890, when he became Engineer of Maintenance of Way of the Baltimore & Ohio Southwestern Ry. He entered the service of the Baltimore & Ohio R. R. in 1901 as a Division Superintendent and in February, 1904, became Chief Engineer.

The following commissioners have been appointed by Governor Hughes, of New York, to have charge of the highways of the state, as provided by the new law which went into effect on Jan. 1: Herbert E. Cook, of Denmark, N. Y.; Samuel P. Hooker, of Le Roy, N. Y., and Thomas W. Allen, of New York City. Mr. Hooker, who will be Chairman of the Commission, was formerly a State Senator and has given special attention to highway legislation. Prof. Cook is Dean of the School of Agriculture of St. Lawrence University, and Mr. Allen is a graduate of the Civil Engineering Department of Union College and has had considerable experience in railroad and river and harbor work.

Catalogs Worth Having.

Engineers and contractors should have on file the latest catalogs of machines, tools and supplies that they use. In sending for catalogs reviewed or advertised in this paper, you will confer a favor on us if you will write direct to the advertisers and state that you saw the catalog mentioned in ENGINEERING-CONTRACTING If you are in the market for tools, machinery or supplies, tell us and we will notify promptly the leading manufacturers.

No. 1043. **Derricks and Derrick Fittings.**—The Terry & Tench Co., 131st and Lexington av., New York.

A 52-page catalog, beautifully printed, describing and illustrating the derricks of different types made by this company. All kinds of derrick fittings are also shown. This company also makes an all steel derrick car. Photographs are also shown of installations of their derricks.

No. 1044. **Steel Forms.**—C. H. Schub, 1947 Broadway, New York.

A folder telling of metal forms for building concrete houses. The forms are used in units, and it is stated can be adapted for any concrete work in connection with buildings.

No. 1045. **Water Filters.**—Hungerford & Terry, Pennsylvania Building, Philadelphia, Pa.

A 32-page catalog devoted to pressure and gravity filters, continuous and intermittent water softeners and Burtonizing apparatus for breweries. Also plants for the removal of iron from water.

No. 1046. **Motors.**—Eck Dynamo & Motor Co., Belleville, N. J.

A catalog consisting of a number of bulletins telling of the Eck motors and electrical apparatus. This company makes a specialty of a protected and enclosed type of motor. Tables of dimensions are given.

No. 1047. **Metal Hose.**—The American Metal Hose Co., 173 La Fayette St., New York.

A 12-page catalog handsomely illustrated showing the uses of the all metal hose. It is stated that the life of this hose is much longer than of hose made of other materials. The hose can be used for steam, air, gas, acid or ammonia.

No. 1048. **Concrete Clamps.**—The Dietrichs Clamp Co., 13½ Kaufman Av., Little Ferry, N. J.

A folder showing the use of these clamps for holding concrete forms, and explaining the method of building houses, walls, silos, etc., by the use of two form boards only. It is stated that this method saves about 90 per cent of the lumber ordinarily required for forms.

No. 1049. **Pipe and Boiler Insulation.**—H. W. Johns-Manville Co., New York.

This 72-page catalog is devoted to problems of insulating all kinds of heated and cooled surfaces, such as pipes, boilers, furnaces, flues and ducts as well as insulation for refrigerating and cold storage work. The book is very complete and handsomely illustiated. It is known as catalog No. 100.

TABLE II.—SHOWING QUANTITIES OF CEMENT, SAND AND BROKEN STONE REQUIRED FOR 100 SQ. FT. OF SIDEWALK SEPARATELY FOR BASE AND FOR SURFACE FINISH FOR DIFFERENT PROPORTIONS OF CONCRETE AND DIFFERENT THICKNESSES OF WALK.

Thickness, ins.	1—2—4			1—2—5			1—3—6			Thickness, ins.	1—1		1—1½		1—2	
	Cement, bbls.	Sand, cu. yds.	Stone, cu. yds.	Cement, bbls.	Sand, cu. yds.	Stone, cu. yds.	Cement, bbls.	Sand, cu. yds.	Stone, cu. yds.		Cement, bbls.	Sand cu. yds.	Cement, bbls.	Sand, cu. yds.	Cement, bbls.	Sand, cu. yds.
2½	1.00	0.32	0.65	0.89	0.29	0.73	0.69	0.34	0.68	½	0.61	0.093	0.52	0.124	0.45	0.139
3	1.20	0.39	0.78	1.08	0.35	0.88	0.84	0.41	0.82	¾	0.91	0.139	0.77	0.186	0.67	0.209
3½	1.40	0.45	0.91	1.25	0.41	1.02	0.97	0.47	0.95	1	1.12	0.185	1.03	0.247	0.90	0.278
4	1.61	0.52	1.04	1.43	0.47	1.18	1.12	0.55	1.09	1¼	1.52	0.232	1.29	0.308	1.12	0.347
4½	1.80	0.58	1.17	1.61	0.53	1.32	1.25	0.61	1.22	1½	1.83	0.278	1.55	0.371	1.34	0.418
5	92	0.65	1.30	1.79	0.59	1.47	1.39	0.68	1.36	1¾	2.03	0.325	1.81	0.433	1.57	0.487
6	45	0.78	1.57	2.17	0.71	1.78	1.58	0.82	1.64	2	2.33	0.371	2.06	0.494	1.79	0.556

CONTRACT NEWS

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We shall welcome any news notes that our readers may send in. Notes of contracts awarded, bidding prices, etc., will be especially acceptable.

BIDS ASKED

Bridges.

Bids Open.		See Issue.
Jan. 13.	York, Neb.	Dec. 23
Jan. 13.	Kearney, Neb.	Dec. 30
Jan. 13.	Beaver City, Neb.	Jan. 6
Jan. 14.	Urbana, Ill.	Jan. 6
Jan. 15.	St. Louis, Mo.	Jan. 6
Jan. 15.	Chicago, Ill.	Jan. 6
Jan. 15.	Spartanburg, S. C.	Jan. 13
Jan 16.	Dayton, Ohio	Dec. 30
Jan. 18.	Youngstown, O.	Jan. 6
Jan. 18.	Cedar Rapids, Ia.	Jan. 6
Jan. 18.	Brillion, Wis.	Jan. 13
Jan. 20.	Toledo, O.	Jan. 6
Jan. 20.	Chicago, Ill.	Jan. 13
Jan. 22.	Cincinnati, O.	Jan. 6
Jan. 28.	Cedar Rapids, Ia.	Jan. 13
Jan. 29.	Cincinnati, O.	Jan. 6
Jan. 29.	Cincinnati, O.	Jan. 13
Jan. 30.	Beaufort, N. C.	Jan. 6
Mar. 4.	Paris, Ark.	Jan. 13

Buildings.

Jan. 13.	Fort Stephens, Ore.	Jan. 6
Jan. 13.	New Orleans, La.	Jan. 6
Jan. 14.	Crandon, Wis.	Jan. 6
Jan. 14.	Mont Alto, Pa.	Jan. 13
Jan. 15.	Carthage, Mo.	Dec. 30
Jan. 15.	Carmen, Okla.	Jan. 13
Jan. 16.	Brooklyn, N. Y.	Jan. 6
Jan 16.	Pittsburg, Pa.	Jan. 13
Jan. 18.	Fort Meade, S. Dak.	Dec. 23
Jan. 18.	Geneva, N. Y.	Jan. 6
Jan 18	Albany, New York	Jan. 13
Jan. 18.	Youngstown, O.	Jan. 13
Jan. 18.	Hattiesburg, Miss.	Jan. 13
Jan. 19.	San Jose, Cal.	Dec. 30
Jan. 19.	Milwaukee, Wis.	Jan. 13
Jan. 20.	Springfield, Mass.	Dec. 23
Jan. 20.	Fort Robinson, Neb.	Dec. 30
Jan. 20.	Kansas City, Mo.	Jan. 13
Jan. 20.	Fort Robinson, Neb.	Jan. 13
Jan. 21.	Fort Crook, Neb.	Dec. 30
Jan. 23.	Anderson, S. C.	Dec. 30
Jan. 23.	Portland, Me.	Dec. 23
Jan. 25.	Jacksonville, O.	Jan. 13
Jan. 27.	Fort Leavenworth, Kan.	Jan. 6
Jan. 28.	Ames, Ia.	Jan. 6
Feb. 1.	Claremore, Okla.	Jan. 6
Feb. 1.	Parkersburg, W. Va.	Jan. 13
Feb 1	Midland, Texas	Jan. 13
Feb. 1	Newcastle, Ind.	Jan 13
Feb. 1.	Los Angeles, Cal.	Jan. 13
Feb. 4.	San Antonio, Texas	Dec. 30
Feb. 11.	Dulce, N. Mex.	Jan. 13
Feb. 11.	Clarinda, Ia.	Jan. 13
Feb. 15.	Grand Rapids, Mich.	Jan. 13
Feb. 15.	Shenandoah, Ia.	Jan. 13
Feb. 27	La Salle, Ill.	Jan. 13
Mar 1	Omaha, Neb.	Jan 6

Roads and Streets.

Jan 13.	Shenandoah, Ia.	Jan 13
Jan. 14.	Flemington, N. J.	Dec. 23
Jan. 15.	Lafayette, Ind.	Jan. 6
Jan. 15.	Tacoma, Wash.	Jan 13
Jan. 16.	Cleveland, O.	Dec. 30
Jan. 18.	Pensacola, Fla.	Dec. 23
Jan. 18.	Indianapolis, Ind.	Jan 6
Jan. 18.	Naperville, Ill.	Jan 6
Jan. 18.	Lisbon, O.	Jan 13
Jan. 19.	Huntsville, Ala.	Jan. 6
Jan. 19.	Noblesville, Ind.	Jan. 13
Jan. 20.	Marion, Ind.	Jan. 6
Jan. 20	Baltimore, Md.	Jan 13
Jan. 20.	Chicago, Ill.	Jan 13
Jan. 21.	Akron, Ohio	Jan 13
Jan. 22.	Cincinnati, O.	Jan. 6
Jan. 26.	Annapolis, Md.	Jan 13
Jan 26.	Anderson, Ind.	Jan 13
Jan 30	Cleveland, O.	Jan. 13
Feb 1	Olympia, Wash.	Dec. 23
Feb 3	Cleveland, O.	Jan 6
Feb 3	Bluffton, Ind.	Jan 13
Feb. 5	Lebanon, Ind.	Jan 13
Feb 5	Anderson, Ind.	Jan 13
Feb 11	Appleton, Wis.	Dec 30

Sewers.

Jan 13	Polk, Pa.	Dec 23
Jan 14.	Danville, Pa.	Dec 23
Jan 15	Tonawanda, N. Y.	Jan 13
Jan 15.	Toronto, Ont.	Jan 13
Jan. 18	Roanoke, Va.	Jan 6
Jan. 18.	Naperville, Ill.	Jan 6
Jan 18	Zanesville, O.	Jan 13
Jan 18	New York, N. Y.	Jan 13
Jan. 19.	East Point, Ga.	Dec 30
Jan. 20	Toledo, O.	Jan 13
Jan. 21	Guthrie, Okla.	Jan 13
Jan 21.	Sylvania, O.	Jan 13
Jan. 22.	Louisville, Ky.	Jan 6
Jan. 25.	Purcell, Okla.	Jan 6

Water Supply.

Feb. 5.	Key West, Fla.	Jan 13
Jan. 15.	Roanoke, Va.	Jan. 6
Jan. 18.	Moundridge, Kan.	Jan. 6
Jan. 18.	Wellington, Kan.	Jan. 6
Jan. 19.	East Point, Ga.	Dec. 30
Jan. 19.	Los Angeles, Cal.	Jan. 13
Jan. 20.	Augusta, Kan.	Jan. 13
Jan. 21.	Fort Hancock, N. J.	Jan. 13
Jan. 25.	Daytona, Fla.	Jan. 6
Jan. 29.	Carlyle, Ill.	Jan. 13
Feb. 1.	Denison, Ia.	Jan. 6
Feb. 5.	Key West, Fla.	Jan 6

Miscellaneous.

Jan. 15.	Ottawa, Ont.	Steamer	Dec 2
Jan. 19.	Toronto, Ont.	Hydraulic Dredge	Jan. 6
Jan. 20.	Boston, Mass.	Refuse Disposal	Dec. 30
Jan. 21.	Detroit, Mich.	Wooden Tug	Dec. 30
Jan. 22.	Fort Sam Houston, Tex.	Steel Cells	Jan 13
Feb. 5.	St. Louis, Mo.	Street Lighting	Jan. 13
Feb. 8.	Prescott, Ariz.	Fence	Jan 13
Feb. 13.	Hawaii	Dry Dock	Dec. 9
Jan. 14.	Charlottetown, P. E. I.	Freight Shed	Jan 13
Jan. 14.	Newburg, O.	Street Lighting	Jan 14

Excavation, Earth and Rock

Jan. 15.	Mobile, Ala.	Dredging	Dec 23
Jan. 15.	Mangum, Okla.	Railroad Grading	Dec. 16
Jan. 15.	Fort Dodge, Ia.	Tile Drain	Jan. 6
Jan. 15.	Urbana, Ill.	Tile Drain	Jan. 13
Jan. 16.	Goshen, Ind.	Ditch	Dec. 30
Jan 16.	Greenville, O.	Ditch Work	Jan 13
Jan. 18.	Bayou Goula, La.	Dredging	Dec. 30
Jan. 18.	Des Moines, Ia.	Ditch Work	Dec. 30
Jan. 20.	Rector, Ark.	Ditch Work	Jan 6
Jan 23.	New London, Conn.	Dredging	Dec 30
Jan. 25.	Shamokin, Pa.	Tunnel	Jan 13
Jan. 27.	Crookston, Minn.	Ditch Work	Jan 6
Jan. 30.	Sterling, Ill.	Ditch Work	Jan 13
Feb 1.	Sioux City, Ia.	Ditch Work	Jan 6
Feb. 10.	Logan, Ia.	Ditch Work	Jan 6

Materials, Machines, Supplies, Tools, Etc.

Jan. 13.	Baltimore, Md.	Furniture, Wagons, Etc.	Jan 6
Jan 14	Kansas City, Kan.	Water Pipe, Etc.	Dec 30
Jan. 14	Hobart, Okla.	Pumping Engine	Jan 6
Jan. 15.	Portland, Ore.	Portland Cement	Dec 2
Jan. 16.	St. Catharines, Ont.	Timber, Castings, Etc.	Jan 6
Jan. 15	Dallas, Texas	Air Compressor	Jan 13
Jan. 18	Washington, D. C.	Sanitary Fixtures, Pipe, Etc.	Dec. 30
Jan 18	Chicago, Ill.	Cement	Jan 6
Jan 18	[illegible], N. J.	Water Pipe, Etc.	Jan 13
Jan 19	East Point, Va.	Pump, Generator, Boilers, Etc.	Dec 30
Jan 19	[illegible]	Water Works Material	Jan 13
Jan 19	[illegible], Md.	Meter Fitting [illegible]	Jan 13
Jan 19	Los Angeles, Cal.	Pipe	Jan 13
Jan 20	Grand Island, Neb.	Chemical Engine	Jan 6
Jan 20	[illegible], Mo.	[illegible]	Jan 13
Jan 21	Charleston, S. C.	Pump	Jan 13
Jan 20	Baltimore, Md.	Lubricating Oil	Jan 13
Jan 20	Baltimore, Md.	Pipe, Tools, Paving Materials, Etc.	Jan 13
Jan 20	Baltimore, Md.	Garbage Carts	Jan 13
Jan 21	Fort Dade, Fla.	Gun Lift Apparatus	Dec 30
Jan 25	North Vancouver, B. C.	Road Machinery	Dec 23
Jan 25	Dayton, Fla.	Pipe, Engines	Jan 6
Jan 27	Washington, D. C.	Steel Wire Rope, Fence, Etc.	Jan [illegible]
Jan 26	Frankfort, Ky.	Filing Cases	Dec 30
Jan. 29.	Ottawa, Ont.	Cement	Jan 6
Jan. 30	Mare Island, Cal.	Elevator	Jan 13
Feb 1	Leavenworth, Kan.	Pipe, Etc.	Jan 13
Feb. 2.	Richland Center, Wis.	Pump	Jan 6
Feb 2	Kenosha, Wis.	Pumping Engine	Jan 13
Feb 5	Key West, Fla.	Condenser, Filter, Etc.	Jan 6
Feb 5.	Banff, Alberta	Sewer Pipe	Jan 13
Feb. 17.	Milwaukee, Wis.	Gas Producer and Gas Engine, Electric Light Plant	Jan 13
Feb. 22	Winnipeg, Man.	Pump, Motor	Dec 9

BIDS ASKED

Bridges.

Bids are asked on following work, the notes being arranged alphabetically by states.

Paris, Ark.—Until Mar. 4, by Fred N. Carter, County Clerk, for constructing six steel and iron bridges.

Cedar Rapids, Ia.—Until 3 p. m., Jan. 28, by L. J. Storey, City Clerk, for constructing a new bridge for pedestrians and vehicles of a riveted truss and reinforced concrete floor over Indian Creek at 30th St., East.

Chicago, Ill.—Until noon, Jan. 20, by [illegible], Clerk, Sanitary District of Chicago, American Trust Bldg., for the fabrication, erection and completion of the superstructures of two railroad bridges crossing the North Shore Channel of the Sanitary District of Chicago, one in Niles Township and one at Grant St. in Evanston.

Cincinnati, O.—Until noon, Jan. 29, by County Commissioners, Fred Dreihs, Clerk, for the following county work: Under Specifications No. 812—For the building of a concrete bridge on the Compton Road near the German Road, Springfield Township.

Spartanburg, S. C.—Until Jan. 15, by W. F. West, Supervisor, for building steel bridges over Enoree River at Yarborough and [illegible] bridge sites.

Brillion, Wis.—Until Jan. 18, according to reports, by J. F. Otto, of Board of Supervisors, at office of Town Clerk, for constructing arch stone bridge with approaches over north branch of Manitowoc River, in Section 30.

Buildings.

Bids are asked on following work, the notes being arranged alphabetically by states.

Los Angeles, Cal.—Until 2 p. m., Feb. 1, by County Supervisors, C. G. Keyes, Clerk, for the construction of an administration building, a medical pavilion and a consumptive ward at the County Hospital. Bids are asked on (1) general contract for construction of the three buildings; (2) contract for plumbing and gas fitting; (3) contract for vacuum steam heating system; (4) contract for elevators. Hudson & Munsell, Architects, [illegible] Stimson Bldg., Los Angeles.

La Salle, Ill.—The Western Clock Mfg. Co., E. Roth, Secretary, La Salle, Ill., will receive bids until Feb. 27, for building a 2-story store room and a 1-story factory addition in the spring. The store room will be 50 ft. by 222 ft. and the factory addition will be 137 ft. by 222 ft. Both buildings will be of brick, concrete and steel.

Newcastle, Ind.—Until 10 a. m., Feb. 1, by W. L. Risky, County Auditor, for constructing brick barn at County Jail.

Clarinda, Ia.—Until 2 p. m., Feb. 11, by James Knox Taylor, Supervising Architect, Washington, D. C., for construction, complete, of U. S. Post Office at Clarinda.

Shenandoah, Ia.—Until 3 p. m., Feb. 15, by James Knox Taylor, Supervising Architect, Washington, D. C., for the construction, including plumbing, gas piping, heating apparatus, electric conduits and wiring of the U. S. Post Office at Shenandoah.

Grand Rapids, Mich.—Until Feb. 15, by Board of Education, for erecting new high school building on Fountain St.

Kansas City, Mo.—Until 2 p. m., Jan. 20, by Board Public Works, Robert W. Goodnow, Secretary, for constructing public comfort station on Main St. Bids will be received for the plumbing, marble work, heating and gas fitting in one contract, and for the balance of the work, excepting bronze work, in another contract. Walter P. Birmingham, Architect, 202 1st National Bank Bldg.

Hattiesburg, Miss.—Until Jan. 18, at office of the President of the New Orleans & Northwestern R. R. Co. at New Orleans for the construction of a passenger depot at Hattiesburg, Miss.

Fort Robinson, Neb.—Until 1 p. m., Jan. 20, by Capt. F. T. Arnold, Constructing Q. M., for construction of a building for transformer substitute station.

Dulce, N. Mex.—Until 2 p. m., Feb. 11, by the Commissioner of Indian Affairs, Washington, D. C., for constructing a school at the Jicarella School in New Mexico. Further information may be obtained from George L. Williams, Superintendent, Dulce, N. Mex.

Albany, N. Y.—Until 3 p. m., Jan. 18, by Board of Contract and Supply, Isidore Wachsman, Secretary, for repairs to public bath No. 3. Bond for $800 required with bid.

Carmen, Okla.—Until Jan. 15, by G. W. Bruce, Secretary of Odd Fellows Home Board, Guthrie, Okla., for erection of an addition to the Odd Fellows Home in Carmen.

Jacksonville, O.—Until Jan. 25, by A. A. Campbell, Clerk Board of Education, for erecting public school building. Franklin Packard, Architect, Columbus, O.

Youngstown, O.—Until noon, Jan. 18, by Board of Education, W. N. Ashbaugh, Clerk, for labor and materials, for the plastering and slate base work for the Garfield School building

Mont Alto, Pa.—Until 5 p. m., Jan. 14, by Samuel G. Dixon, State Commissioner of Health, 1900 Race St., Philadelphia, for the furnishing of all labor and material necessary for the construction and erection of gas lighting fixtures in infirmary, dining building, twin house, laboratory, morgue and one-story building, at the Pennsylvania State South Mountain Sanatorium, near Mont Alto, Franklin County.

Pittsburg, Pa.—Until 10:30 a. m., Jan. 16, by Edward G. Lang, Director Public Safety, for erection of a public comfort house on Oliver Av. Plans, etc., with John P. Brennan, Assistant Superintendent Bureau of Building Inspection, 6th Av. and Cherry Alley.

Midland, Tex.—Until Feb. 1, by Building Committee, Volney Johnson, Secretary, for plans and bids for a Christian college at Midland, to be of brick or stone and to cost not more than $35,000.

Milwaukee, Wis.—Until 2 p. m., Jan. 19, by Trustees Public Museum, for furnishing and setting all the cut stone work necessary and required for the addition to the Public Museum Building on 8th and 9th Sts. Ferry & Clas, Architects. Certified check for $900 required with bid.

Parkersburg, W. Va.—Until Feb. 1 (extension of time) for constructing new First M. E. church in this city.

Roads and Streets.

Bids are asked on following work, the notes being arranged alphabetically by states:

Chicago, Ill.—Until noon, Jan. 20, by the South Park Commissioners, E. G. Shumway, Secretary, 57th St. and Cottage Grove Ave., for 35,000 sq. yds., of paving on Michigan Ave., between 12th St. and Jackson St. Bids will be received on sheet asphalt, creosoted wood block, or any bituminous concrete pavement for which the bidder may submit specifications.

Anderson, Ind.—Until 2 p. m., Feb. 5, by W. T. Richards, County Auditor, for constructing gravel road along Henry-Madison County line.

Anderson, Ind.—Until 10 a. m., Jan. 26, by Wm. T. Richards, County Auditor, for constructing the following roads: One in Boone Township, 14,494 ft.; three in Adams Township, 11,050, 14,025 and 11,857 ft.; three in Anderson Township, 2,896, 4,450 and 5,403 ft.; two in Duckcreek Township, 10,575 and 10,548 ft.; two in Fall Creek Township, 1,459 and 4,007 ft.; three in Jackson Township, 10,680 10,750 and 13,200 ft.; two in Lafayette Township, 14,775 and 5,465 ft.; three in Monroe Township, 10,634, 5,264 and 10,657 ft.; one in Pipe Creek Township, 2,592 ft.; three in Richland Township, 9,407, 15,800 and 12,684 ft.; two in Stony Creek Township, 10,373 and 3,431 ft.

Bluffton, Ind.—Until 10 a. m., Feb. 3, by O. P. Garrett, County Auditor, for constructing stone road in boundary line between Adams and Wells Counties.

Lebanon, Ind.—Until 2 p. m., Feb. 5, by B. F. Heidrick, County Auditor, for constructing gravel road 9,160 ft. long.

Noblesville, Ind.—Until 1 p. m., Jan. 19, by N. W. Cowgill, County Auditor, for constructing following gravel roads: No. 82 in Jackson Township, 5,963 ft. long, estimated cost $2,882; No. 92, in White River Township, 7,986 ft. long, $4,500; No. 94, in Jackson Township, 10,644 ft. long, $5,509; No. 95, in Jackson Township, 9,767 ft. long, $6,168; No. 96, in Washington Township, 3,965 ft. long, $7,373; No. 99, in Fall Creek Township, 7,929 ft. long, $5,222; No. 101, in Adams Township, 15,545 ft. long, $8,531.

Shenandoah, Ia.—Until 6 p. m., Jan. 13, by Thos. W. Keenan, City Clerk, for paving portion of Pattle Ave. with repressed vitrified paving blocks on concrete base.

Annapolis, Md.—Until noon, Jan. 26, by County Commissioners, W. W. Webb, Clerk, for grading and macadamizing 1¼ miles of road from Linthicums' blacksmith shop to Shepley Station. E. H. Hayman, County Road Engineer.

Baltimore, Md.—Until 11 a. m., Jan. 20, by B. T. Fendall, City Engineer, for sheet asphalt repairs for whole city during 1909.

Akron, O.—Until noon, Jan. 21, by County Commissioners, for macadamizing one mile of road in Portage Township. Estimated cost is $8,671. Certified check for $300 required with bid. Plans, etc., with County Commissioners at Akron, and with James C. Wonders, State Highway Commissioner, Columbus.

Cleveland, O.—Until 11 a. m., Jan. 30, by County Commissioners, Wm. F. Black, Clerk, for the grading, draining and improving of York Road from Wooster Pier to Royalton Road in Parma and Royalton Townships. A. B. Lea, County Surveyor. Certified check for $1,000 required with bid.

Lisbon, O.—Until 1 p. m., Jan. 18, by Chas. H. Cobourn, County Auditor, for grading and improving Old Spring Grove Camp Ground Road. Certified check for $200 required with bid. B. M. French, County Engineer.

Tacoma, Wash.—Until 11 a. m., Jan. 15, by I. M. Howell, County Auditor, for improving Hornaday-Peterson Road for a distance of 5,960 ft.

Sewers.

Bids are asked on following work, the notes being arranged alphabetically by states:

New York, N. Y.—Until 2 p. m., Jan. 18, by John F. Ahearn, President Manhattan Borough, for constructing sewer in 55th St.

Tonawanda, N. Y.—Until Jan. 15, by Board Public Works, for constructing complete sewer system, including lifting station in the eastern section of this city. An appropriation of $22,000 has been made for the work.

Sylvania, O.—Until noon, Jan. 21, by W. B. Harris, Village Clerk, for labor and material for constructing a sewer system. Riggs & Sherman, Engineers, 613 The Nasby, Toledo, Ohio.

Toledo, O.—Until noon, Jan. 20, by Board Public Service, Reynold Voit, Secretary, for constructing several local sewers.

Zanesville, O.—Until noon, Jan. 18, by Board Public Service, J. T. Hahn, Clerk, for constructing storm pipe sewers in Ohio, Indiana and Virginia Sts. Certified check for $500 required with bid.

Guthrie, Okla.—Until 4 p. m., Jan. 21, by City Clerk, for constructing main sanitary sewer No. 7, the work including 5,200 ft. 8-in. vitrified sewer pipe, including all Y's; 15 manholes, 320 cu. yd. rock; 1,700 ft. lumber B. M.

Toronto, Ont.—Until Jan. 15 (extension from Dec. 15) by Mayor Joseph Oliver, for constructing Sec. 3 of high level intercepting sewer, the work consisting of about 6,380 ft. of 7½ to 8½-ft. circular sewer.

Water Supply.

Bids are asked on following work, the notes being arranged alphabetically by states:

Los Angeles, Cal.—Until Jan. 19, by H. J. Lelande, City Clerk, for constructing reinforced concrete reservoir in Elysian Park. Plans, etc., with Department of Parks.

Key West, Fla.—Plans and specifications for remodeling pumping and distilling plant, etc., at Key West Barracks, Fla., are on file at office of Engineering-Contracting, 355 Dearborn St., Chicago, Ill. Bids are asked until Feb. 5, as stated in our proposal advertising columns.

Carlyle, Ill.—Until Jan. 29, by A. A. Wade, City Clerk, for improvements to city water works and electric light building.

Augusta, Kan.—Until 3 p. m., Jan. 20, by Timothy Sexton, City Clerk, for constructing water works. Burns & McDonnell, Engineers, Kansas City, Mo.

Fort Hancock, N. J.—Until 2 p. m., Jan. 21, by W. J. Hawkins, Constructing Q. M., for installing water and sewer connections to one double set of N. C. O. quarters and two double sets of firemen's quarters at Fort Hancock.

Miscellaneous.

Bids are asked on following work, the notes being arranged alphabetically by states:

Prescott, Ariz.—Fence.—Until 3:30 p. m., Feb. 8, by Lieut. K. P. Williams, Constructing Q. M., for constructing post fence at Whipple Barracks.

St. Louis, Mo.—Street Lighting—Until Feb. 5, by Board Public Improvements, W. B. Dryden, Secretary, for street lighting for a term of ten years.

Newburg (P. O. Cleveland), O.—Street Lighting.—Until Jan. 14, by Board Public Service, E. L. Lawrence, Clerk, for lighting streets with electricity, gas or incandescent vapor lights for a period of one, three or five years.

Fort Sam Houston, Tex.—Steel Cells.—Until Jan. 22, by Col. J. L. Clem, Quartermaster, U. S. A., for installing cage of ten steel cells in guardhouse at Fort Sam Houston.

Charlottetown, P. E. I.—Freight Shed.—Until Jan. 14, by D. Pottinger, General Manager, Moncton, N. B., for construction of a freight shed on the wharf at Charlottetown.

Excavation, Earth and Rock.

Bids are asked on following work, the notes being arranged alphabetically by states:

Sterling, Ill.—Ditch Work.—Until 2 p. m., Jan. 30, by Drainage Commissioners of Hume, at law office of Frank J. Bowman, Sterling, where plans, etc., can be seen, for digging drainage ditch, requiring removal of 24,214 cu. yds. of earth.

Urbana, Ill.—Tile Drain.—Until Jan. 15, by Commissioners of Kankakee Drainage District, William B. Weber, Urbana, for constructing tile drain, including 12,600 ft. of 16-in. to 22-in. tile.

Greenville, O.—Ditch Work.—Until 10 a. m., Jan. 16, by James R. Marker, County Engineer, for constructing Ditch No. 697 in Wayne Township, estimated to cost $1,028, and including 910 ft. of open work and 6,168 ft. of 6-in. to 15-in. tile. Bids are also asked until 10:30 a. m., Jan. 16, for constructing Ditch No. 695 in German and Neave Townships, estimated to cost $2,496.

Shamokin, Pa.—Tunnel.—Until Jan. 25, by E. A. Rhoads, Shamokin, Superintendent of the Mineral Railroad & Mining Co., for driving a tunnel from the No. 4 seam to the No. 2 seam north in No. 1 slope level at the Cameron Colliery. Total distance to be driven is about 600 ft., to be driven by machine work. The company will furnish steam and compressor.

Materials, Machines, Supplies, Tool, Etc.

Bids are asked on following work, the notes being arranged alphabetically by states:

Los Angeles, Cal.—Pipe.—Until Jan. 19, by H. J. Lelande, City Clerk, for furnishing galvanized pipe and fittings for the use of the Park Department as follows: 12,000 ft. of 2-in. and 10,000 ft. of 1-in. galvanized water pipe, tees, ells, iron gate valves, unions, rough hose bibbs, garden valves, brass gate valves, stop cocks, etc.

Mare Island, Cal.—Elevator.—Until Jan 30, by Bureau Yards and Docks, Navy Department, Washington, D. C., for installing electric elevator in the general store house at U. S. Navy Yard, Mare Island, Cal.

Washington, D. C.—Steel, Wire Rope, Fuses, Etc.—Until 10:30 a. m. Jan. 25, by Capt. F. C. Boggs, General Purchasing Officer, Isthmian Canal Commission, for furnishing under Circular 487 steel, iron castings, chain, wire rope, exhaust heads, canvas, dredge sleeves, blasting caps, fuses, connecting wire, insulating tape, etc.

Leavenworth, Kan.—Pipe, Etc.—Until 10 a. m. Feb. 1, by R. V. Ladow, Superintendent Prisons and Prisoners, Department of Justice, Washington, D. C., for furnishing and delivering at U. S. penitentiary at Leavenworth, cast iron pipe fittings and vitrified clay pipe and fitting for drainage and sewer purposes.

Annapolis, Md.—Motor, Filing Case, Etc.—Until 10 a. m. Jan. 19, by Bureau of Supplies and Accounts, Navy Department, Washington, D. C., to furnish a quantity of naval supplies at the Naval Academy, Annapolis, Md., as follows: Sch. 800: Motor Generator Set, Filing Case, Tables, Desk, Lamp, etc. Sch. 804: Pipe, etc., Dynamo, Klingerit, Steam Whistle, Tubes, Packings, Bulletin Boards, Laboratory Supplies, Books, Pneumatic Typewriter Keys, Filing Cabinet, Paint, Stationery, Beam Compass, etc.

Baltimore, Md.—Pipe, Tools, Paving Materials, Etc.—Until 11 a. m. Jan. 20, by B. T. Fendall, City Engineer, for furnishing City Engineer's Department for general purposes during 1909 the following: Lumber, Sand, Cobble or Rubble Paving Stone and Broken Stone, Vitrified Paving Blocks, Vitrified Sewer Pipe, Asphalt Blocks, American Portland Cement, Curbstone, Gutterstone and Flagstone, Granite Paving Blocks, Sidewalk and Sewer Brick, Sheet Asphalt repairs for whole city, Tools and Hardware, Paints, Oils, etc., Sewer Traps, Inlet Covers and Dripstones of North River Bluestone, Square and Oval Cast-Iron Manhole Frames and Covers, Cast-Iron Sewer Pipes, Cast-Iron Inlet Covers, etc.

Baltimore, Md.—Garbage Carts.—Until 11 a. m., Jan. 20, by J. L. Wickes, Commissioner of Street Cleaning, for furnishing the Department of Street Cleaning with 15 garbage carts.

Baltimore, Md.—Lubricating Oils.—Until 11 a. m., Jan. 20, by Alfred M. Quick, Water Engineer, for furnishing and delivering to the Water Board such lubricating oils as may be required for the year ending Dec. 31, 1909.

Union, N. J.—Water Pipe, Etc.—Until 8:30 p. m., Jan. 18, by John F. Woods, Clerk Union Township, Odd Fellows Hall, Lyndhurst, N. J., for materials approximately as follows: 1,750 ft. 10-in. bell and spigot cast-iron water pipe, 5,000 ft. 6-in. bell and spigot cast-iron water pipe, 8,000 ft. 4-in. bell and spigot cast-iron water pipe, 3 10-in. gate valves, 11 6-in. gate valves, 33 4-in. gate valves, 20 fire hydrants. R. M. Watson, Township Engineer, 90 Park Ave., Rutherford, N. J.

Charleston, S. C.—Pump.—Until Jan. 20, by J. H. Dingle, City Engineer, for one 450-gallon per minute vertical centrifugal pump, with electric motor for operating same.

Dallas, Tex.—Air Compressor.—Until 3 p. m., Jan. 15, by J. B. Winslett, City Secretary, for furnishing the city with one air compressor, to be duplex with compound steam and two-stage air cylinders, and to be designed that it may run either condensing or non-condensing as required. Compressor shall be capable of furnishing not less than 700 cu. ft. of free air per minute against a gage pressure of 100 lbs. with steam pressure of from 80 to 100 lbs.

Seymour, Tex.—Water Works Material.—Until Jan. 19, by this city, for the purchase of material necessary in the construction of a system of water works, consisting of return tubular boiler, duplex pump, cast-iron pipe, fire hydrants and valves. Specifications may be had from the O'Neil Engineering Co., Dallas, Tex.

Kenosha, Wis.—Pumping Engine.—Until [illegible] p. m., Feb. 2, by R. H. Moth, Superintendent Water Works, for building and erecting a horizontal cross-compound high-duty pumping engine of 6,000,000 gallons capacity per 24 hours.

Milwaukee, Wis.—Gas Producers and Gas Engine Electric Light Plant.—Until 10:30 a. m. Feb. 17, by Board Public Works, for furnishing and erecting complete, in buildings and on foundations to be furnished by the city, a complete installation of a gas producer and a gas engine electric lighting plant. Certified check for $[illegible] required with bid.

Winnipeg, Man.—Arc Lamps.—Until 11 a. m. Jan 20, by Board of Control, M. Peterson, Secretary, for supply of [illegible] enclosed magnetite arc lamps with necessary station regulating apparatus for controlling same.

Banff, Alberta.—Sewer Pipe.—Until noon Feb. 5, by Howard Douglas, Commissioner of Parks, Banff, for the following sewer pipe and fittings required for extensions to the Banff sewerage system: [illegible] ft. 9-in. and [illegible] ft. 15-in. sewer pipe; [illegible] 6-in. off 15-in. sewer junctions, [illegible] 6-in. off 9-in. sewer junctions.

CONTRACTS LET.

The following contracts have been let recently.

Los Angeles, Cal.—Street Lighting.—Los Angeles Gas & Electric Light Co., for lighting city streets during ensuing year.

Anacostia, D. C.—Building.—Charles J. Cassidy Co., 523 13th St., N. W., Washington, D. C., for erecting $10,000 school for St. Theresa Parish.

Washington, D. C.—Building.—W. A. Kimmel, for building the Ingram Memorial church at 10th St. and Massachusetts Av., to cost $75,000. James H. Warner, 603 [illegible] St., Washington, is Architect.

Washington, D. C.—Church.—F. D. Foster, for erecting a church at Lamont St. and Sherman Av., for a colored Baptist congregation. Lepley & West, Architects.

Pensacola, Fla.—Hotel Building.—C. H. Turner Construction Co., Pensacola, Fla., at about $260,000, for erecting 7-story reinforced concrete hotel for Pensacola Hotel Co.

Burlington, Ia.—Ditch Work.—R. H. McWilliams, Mattoon, Ill., at 17½ cts. per cu. yd., for 22,000 cu. yds. of open ditch work for the Gates-Iowa drain for the County Supervisors. Harmon Engineering Co., Peoria, Ill., Engineers.

Lewiston, Idaho.—Paving.—Warren Construction Co., at $131,000, for paving for this city.

Indianapolis, Ind.—Schauer & Roesinger are reported to have been awarded contract for constructing the Brightwood sewer for this city to cost $165,000. This contract was previously reported as having been let to John Jenkins.

Winchell, Ill.—Grading.—P. T. Walsh Construction Co., Davenport, Ia., has a contract for grading property of Rock Island R. R., where the company's new mine shaft is to be sunk just east of Winchell.

Hays City, Kan.—Water Works Enlargement.—Frank A. Hurlburt & Co., Kansas City, for enlargement of city water works system.

Alexandria, La.—City Hall.—Southern Building Co., Louisville, Ky., for constructing new city hall for this city.

New Orleans, La.—Paving.—Etta Contracting Co., and the Barber Asphalt Co., for paving a number of streets for the city.

St. Louis, Mo.—Block Signals.—Union Switch & Signal Co., of Swissvale, Pa., for the installation of a system of block signals on the Frisco to cover over 838 miles of trackage. The contract amounts to over $1,500,000, it is stated.

St. Joseph, Mo.—Sewer.—Laird Construction Co., at $1,229, for constructing a sewer in District No. 52.

Haddonfield, N. J.—Pipe Laying.—New Jersey Contracting & Construction Co., Camden, N. J., at $8,910, for laying suction pipe for this city.

Niobrara, Neb.—Bridge Work.—C. H. Jones, Niobrara, for rebuilding government bridge over Niobrara River at this place. Work has been started and will be completed within 90 days.

New York, N. Y.—Building Foundation.—J. H. Gray Co., Flatiron Bldg., at $697,000, for constructing foundations for new municipal building.

Columbus, O.—Building.—Henry F. Romiane, Jr., Columbus, at $[illegible], for erecting woman's building at state fair grounds.

Galion, O.—Reservoir.—A. J. Staugh, Galion, at about $7,000, for excavating for the Big Four Ry. reservoir north of this city.

Pittsburg, Pa.—Building.—[illegible] Bros. Co., for general contract for erecting $[illegible] school building for Beltzhoover School Board. Lloyd Bros., Lewis Block, Pittsburg, are the Architects.

Providence, R. I.—School House.—Cruise & Smiley, Pawtucket, R. I., for constructing Veazie St. school for Board of Education.

Stamford, Tex.—Railroad Work.—J. L. Mc-[illegible], Fort Worth, Tex., is reported to have contract for [illegible] the first section of Stamford & Northwestern R. R.

Peshastin, Wash.—Bridge.—J. W. Quigg, Wenatchee, at $[illegible] for constructing [illegible]-ft. [illegible] steel bridge for county.

Bridgeburg, Ont.—Grain Elevator.—William Armstrong, Pittsburg, for erecting grain elevator for the [illegible] Elevator Co. to replace structure destroyed by fire.

PROJECTED WORK.

Bridges.

Items Arranged Alphabetically by States.

San Francisco, Cal.—The A. T. & S. F. Ry. Co. is to erect a new steel bridge for its [illegible] line crossing over the Merced River in the San Joaquin Valley. H. C. Phillips, Los Angeles, Cal., is Chief Engineer.

Grand Junction, Colo.—The State Legislature is to be asked to appropriate $[illegible] for the construction of a bridge at the foot of Main St. M. C[illegible] is interested.

Des Moines, Ia.—Various railroads interested have agreed to construct a $[illegible] viaduct in this city. The viaduct proper will be about 1,200 ft. long, while the two approaches will be about 400 ft. each. It will be built of reinforced concrete. The railroads interested are Rock Island, the Burlington, Des Moines Union Ry. and the Minneapolis & St. Louis. A. L. Morgan, Des Moines, Ia., is Chief Engineer Des Moines Union Ry.

Cedar Rapids, Ia.—City Engineer is preparing plans for a new steel bridge over Indian Creek at 30th St. L. J. Storr is City Clerk.

Dubuque, Ia.—City Engineer has completed plans and estimates for the proposed viaduct at Johnson and Garfield Avs., to extend to Sycamore St. The structure will cost about $10,000.

Bonners Ferry, Idaho.—Committee has been formed here with J. E. [illegible], President, to secure an appropriation of $[illegible] to build a bridge across the Kootenai River at this place.

Indianapolis, Ind.—The following bids were received Dec. 30 by the County Commissioners for constructing a new bridge over Fall Creek at Capital Av.: George W. Fife, $60,662; Mansfield Engineering Co., $[illegible],417; Central State Bridge Co., $73,[illegible]27; Marion County Construction Co., $68,827; M. Defrees, $69,[illegible]78.

Baltimore, Md.—Westinghouse, Church, Kerr & Co., New York City, will report by Jan. 15 to the Merchants' and Manufacturers' Association on the preliminary surveys for the proposed bridge over the Chesapeake Bay, which is being advocated by the Association.

Bar Harbor, Me.—The question of building a bridge or causeway between Bar Harbor and Bar Island is again being agitated.

St. Louis, Mo.—St. Louis & St. Charles Bridge Co. has been incorporated with a capital stock of $[illegible] and will take over the bridge spanning the Missouri River at St. Charles. The incorporators include C. H. Wilcox and G. C. Strauss, Chicago, Ill.

Duluth, Minn.—City officials have approved plans of Great Northern Ry., G. A. Cassiday, Engineer, St. Paul, Minn., for the proposed 2d St. trestle. The work will cost about $13,000, of which the city will pay one-third.

Albany, N. Y.—Hearing will be held Jan. 21 by Col. J. G. D. Knight, U. S. Engineer, on the petition for widening the two railroad bridges at this city.

Massillon, O.—Commissioners of Stark County, Canton, O., are to proceed at once with plans for the installation of a lift bridge over the canal at Main St.

Cincinnati, O.—The Cincinnati Traction Co., Thomas Elliott, Chief Engineer, is to build a bridge over Eastern Av.

Dayton, O.—The Big Four Ry. will commence work this spring on the construction of its new viaduct on the river road south of the city. The county will pay [illegible] per cent of the cost.

Pittsburg, Pa.—The City Council has passed ordinance to sell $[illegible] of bonds for the erection of a bridge over the Allegheny River.

Connellsville, Pa.—County Engineer J. R. Hoge has prepared plans for a retaining wall at the Point Marion bridge.

Harrisburg, Pa.—M. B. Cowden, City Engineer, has been instructed to make plans for bridges at [illegible] and 17th Sts.

Williamsport, Pa.—Viewers have recommended that County Commissioners construct a bridge over the river at Montgomery. The Commissioners will raise $250,000 for bridge building purposes this year.

Fort Worth, Tex.—The C. R. I. & P. R. R. is planning to expend about $500,000 in constructing new steel and concrete bridges in Oklahoma and Texas. C. M. Case, Fort Worth, Tex., is District Engineer.

Milwaukee, Wis.—The city will vote upon the proposition for building a bridge over the Milwaukee River from Wright and Bradfords Sts. and at Oneida St.

Railroads.

Items Arranged Alphabetically by States.

Birmingham, Ala.—Advices from this city state that the Illinois Central R. R., A. S. Baldwin, Chief Engineer, Chicago, Ill., is soon to have surveys made from Haleyville, Ala., to Birmingham. At present the Illinois Central is using the tracks of the Frisco from Jasper to Birmingham, and from Haleyville to Jasper the tracks of the Northern Alabama R. R. are used.

Pine Bluff, Ark.—Meto Valley Ry. Co., according to advices from this place, will have construction work begun shortly on the proposed line from McCreanor south to Pine Bluff. Surveys for this road were made by the Rock Island R. R. over a year ago. E. C. Murray and S. M. Savage, who are interested in lumber lands in Arkansas, are promoting the proposed line, which is to be 12 miles long and will be used for logging purposes. John J. Ball has the contract for building the road.

Victorville, Cal.—The Victor Portland Cement Co. has raised necessary capital of $1,500,000 for the erection of a million-dollar cement plant at Victorville and for building a railroad from the factory to the deposits. The proposed railroad will be standard gage and will be about 10 miles long. Work is to be started this month, it is said. David A. Mulvene is President and John G. Meacham is Secretary.

Atlanta, Ga.—Preliminary meeting of the committee appointed by Gov. Hoke Smith to investigate the feasibility of extending the Western & Atlantic Ry. from Atlanta to the sea was held at the State Capitol at Atlanta on Jan. 6. The only action taken by the Commission at its first meeting was to organize, elect a chairman and select a time for the later meeting at which the active work for investigation will be undertaken. J. L. McCollum, Atlanta, Ga., is Superintendent, Western & Atlantic R. R

Baltimore, Md.—Edward Lauderbach, a capitalist of New York City, has been granted the right-of-way for a railroad through south Maryland. Mr. Lauderbach has spent $500,000 in the partial construction of a line from the Millerville on the P. B. & W. R. R to Drum Point, the deep water harbor in Maryland.

Bay City, Mich.—The Canadian Pacific is reported here as considering the purchase of the Detroit-Mackinac Ry., which connects Bay City and Sheboygan. The Canadian Pacific Ry. already owns the Duluth, South Shore & Atlantic and by constructing a short line between Port Huron and Bay City, the company would secure a through line from Duluth to the Atlantic seaboard. J. G. Sulivan, Montreal, Que., is Assistant Chief Engineer, Canadian Pacific Ry.

Armstead, Mont.—According to announcements of W. A. McCutcheon, of Pittsburg, Pa., President of the Pittsburg-Gilmore R. R. Co., that road will construct a line from Armstead on the Oregon Short Line to Salmon, Ida., this year. The new road will tap one of the richest mineral districts in the state of Idaho. Over $100,000 is already said to have been expended for surveys of the proposed line.

Jefferson City, Mo.—The Oklahoma & Golden City R. R. Co., chartered in Oklahoma in 1907, is stated to have secured the necessary capital for beginning construction on its proposed road from Pawhusla, Okla., to Jefferson City, Mo., with a branch to Springfield, Mo. The total mileage will be 340 miles. John Griesel, Golden City, Mo., is General Manager, and has been in charge of the promotion work.

Lincoln, Neb.—The Union Pacific is stated to be planning to build this year a double-track main line west from Omaha through Lincoln, connecting with the present main line at Central City, Neb. In connection with the project the Southern Pacific, a subsidiary company, is to build north on an air line from Denison, Texas, through Topeka to Lincoln. Russel Huntley, Omaha, Neb., is Chief Engineer, Union Pacific.

Marianna, Ark.—H. N. Pharr, 216 Randolph Bldg., Memphis, Tenn., is making surveys for a 9-mile railroad to extend from Marianna to Wister by way of Aubrey.

San Antonio, Tex.—The International & Great Northern Ry., O. H. Crittenden, Chief Engineer, Palistine, Tex., will probably spend about $750,000 this year in relaying the 140-mile division between San Antonio and Laredo with 85-lb. rails and ballasting track. T. J. Freeman, Houston, Tex., receiver for the road, is reported to be in the market for 230 miles of 85-lb. steel rails.

Austin, Tex.—The Stamford & Northern Ry. Co. has filed its charter and proposes to construct a road from Stamford, Tex., to Plainview, Tex., a distance of 185 miles. The road is projected in connection with the extension of the Colorado & Southern System, recently purchased by J. J. Hill. The incorporators include M. G. Spoonts, Fort Worth, Tex., General Attorney of the Colorado & Southern in Texas. Construction on the road was to be started Jan. 11. J. L. McSpadden, Fort Worth, Tex., has the contract for the first section.

Corpus Christi, Tex.—It is reported here that Coleman-Fulton Pasture Co., in which Charles P. Taft, Cincinnati, O., is interested, is to construct a railroad connecting its tract of land in San Patrico with its tract of land in Dimmit County.

Beaumont, Tex.—Beaumont & Great Northern R. R., J. H. Clement, Chief Engineer, Onalaska, Tex., proposes to build a line from Livingston to Beaumont and Sabine Pass.

Electric Railways.

Items Arranged Alphabetically by States.

Phoenix, Ariz.—The Phoenix, Tempe & Mesa Ry. Co., recently incorporated, has secured necessary capital for making preliminary surveys of its proposed route. The Board of Directors include: S. J. Tribolet, L. M. Hoghe, Ike Diamond, Andrew Neilson, Harry J. Bennett, M. L. Vienx and George Hageman.

Fresno, Cal.—Local press reports quote F. S. Granger, Fresno, promoter of the Fresno-Hanford interurban railroad, as stating that construction work on the proposed line will be started on Feb. 1 and that the road will be in operation by July 1. Eastern capitalists are reported to have become interested in the project.

Melrose, Cal.—The Southern Pacific Co. will probably commence construction work soon on its proposed electric line from Melrose to San Leandro.

Santa Ana, Cal.—All the right-of-way for the electric railway between Santa Ana and Huntington Beach has been secured.

Vallejo, Cal.—San Francisco, Vallejo & Napa Valley Electric Railway is stated to have secured necessary capital for constructing its street railway system in the eastern and southern sections of this city, and also for extending its line up the valley from St. Helena to Calistoga. M. McIntyre, Napa, Cal., is General Manager.

Jacksonville, Fla.—Advices from this city state that the Suwanee River Electric Power Co., W. R. Owen, President, Jacksonville, intends to let contracts about Feb. 15 for the construction of its proposed interurban system to connect Jacksonville with Waycross, Valdosta and Tipton, Ga., and with Lake City, Live Oak and other points in Florida. The system will be about 300 miles long. Hydro electric power will be developed on the Suwanee River near White Springs, Fla., where a power station will be erected.

Iowa Falls, Ia.—Steps are being taken to raise funds to make preliminary surveys of the proposed route of the interurban line from Fort Dodge, Ia., to Mason City by the way of Dows. C. C. Wolfe, Parkersburg, Ia., is interested.

Des Moines, Ia.—Dr. N. W. Hansen, Walnut, Ia., and Judge R. L. Parrish, Des Moines, Ia., promoters of the proposed Council Bluffs & Western Interurban Ry., sailed on Jan. 13 for London, where they will endeavor to close a deal for capital with which to build the line.

Grundy Center, Ia.—City will vote on Jan. 20 on granting the Iowa Construction Co. franchise for street railway, electric power plant, gas plant and telegraph system.

Joliet, Ill.—With the prinicipal office in Chicago and nominal capital stock of $50,000, the Chicago, Joliet & Pacific Railroad Co. has been incorporated and proposes to construct a road from Chicago in a southwesterly direction to Joliet and thence through the counties of Will, Grundy, La Salle, Bureau, Henry and Mercer to the city of Keithsburg. The incorporators are I. V. Fuller, W. H. Richardson and Charles F. Blue, of Chicago.

Decatur, Ind.—Surveys for the projected line of the Fort Wayne-Springfield R. R. Co. from Decatur to Portland have been made and capital for construction partly secured. The date for letting contracts is uncertain. A. W. Fishbaugh, Celina, O., is Chief Engineer.

Evansville, Ind.—Surveys have been started for the proposed line of the Evansville, Mt. Carmel & Olney Traction Co. The line will be 70 miles long and construction contracts will probably be let this year. H. H. Von Hippel, Newburgh, Ind., is Chief Engineer.

Louisville, Ky.—Louisville Northern Ry. & Lighting Co. has asked franchise to build a track on State St. from Albany St., the present terminus of the new Albany St. Railway Co., to the city limits.

New Orleans, La.—The New Orleans Ry. & Lighting Co. is to at once begin the construction of its extension out St. Bernard Av. to Gentilly Road.

Jackson, Minn.—The matter of constructing an electric railroad between this city and Spirit Lake, Ia., is under consideration and a committee of which T. J. Knox is Chairman has recommended that a corporation be formed to secure the road.

Joplin, Mo.—The Missouri Western Surety & Investment Co., which is projecting 110 miles of interurban line from Joplin, Mo., to Bentonville, Ark., Siloam Springs and Huntsville, Ark., has set aside $400,000 for construction of the road. Surveys have not been made as yet. C. Propper, Bentonville, Ark., is President.

St. Joseph, Mo.—The Interstate Ry. Co. has completed surveys and secured necessary capital for constructing a double track, rock ballasted, standard gage electric railroad between St. Joseph and Kansas City. The road will be 48½ miles long and will have a maximum grade not exceeding 1 per cent. Joseph Corby, Director of the Corby Estate, is interested.

Kansas City, Mo.—The Missouri Interurban Construction Co. of Kansas City has been incorporated with a capital stock of $30,000. The incorporators are Charles W. McDaniels, Howard W. Gibson and E. H. Thompson.

Springfield, Mo.—Springfield Traction Co. is considering extending its Munroe St. line to the State Normal School.

Houston, Tex.—The Houston Electric Co., David Daly, Manager, is planning a number of improvements and extensions for this year.

Galveston, Tex.—Stone & Webster Syndicate, Boston, Mass., who will build the Galveston and Houston interurban, are engaged in securing right-of-way between Houston and Galveston for the line. Two surveys for the line have already been made and it is believed that actual construction work will be started as soon as the Galveston causeway work is authorized.

Fort Worth, Tex.—C. B. Duffy, St. Louis, Mo., has been in this city for the purpose of forming a company for constructing the proposed Fort Worth & Mineral Wells interurban line. Stewart Harrison is interested.

Brownwood, Tex.—L. P. Comer and G. H. Connell, of Fort Worth, Tex., have submitted a proposition to the local Commercial Club to build a motor railroad from Brownwood to Rising Star. The promoters propose to use 56-lb. rails and possibly to convert the road into a steam line.

Harling, Tex.—The building of an electric railway between Harling and Brownsville is being promoted by Lon Hill, of Harling, Tex.

Dallas, Tex.—Promoters of the proposed interurban railroad from Dallas to Corsicana via Waxahachie with a spur 10 miles in length from Waxahachie to Ennis and from there to Palestine have secured more than half the right-of-way and have made preliminary surveys for about half the route. The distance from Dallas to Palestine by the route of the proposed line is 117 miles. J. V. Watkins, Corsicana, Tex., is interested.

Cleelum, Wash.—City Council has granted franchise to Frank S. Farquhar, Tacoma, Wash., for the proposed Cleelum-Roslin Electric Railway to build a road through the streets of that city. The road will be about 12 miles long.

Centralia, Wash.—A street railway franchise here has been granted to Theo. Hoss, Centralia, Wash., W. J. Patterson and A. Welch, of Portland, Ore. A similar franchise has been granted at Chehalis and it is proposed to operate a line between the two cities, a distance of 4 miles. Most of the right-of-way has been secured and Theo. Hoss is quoted as stating that construction work will be commenced shortly.

Chippewa Falls, Wis.—Chippewa Ry., Light & Power Co., Eau Claire, Wis., has secured right-of-way between Eau Claire and Menomonie and will this spring extend its line from Eau Claire to Menomonie.

Weston, W. Va.—County Court has granted a franchise to Dr. George I. Keener for the construction and operation of an electric railway from Weston to Bendal. According to the terms of the franchise work must be commenced within six months and road must be completed within a year.

Vera Cruz, Mex.—S. Pearson & Son, Ltd., builders and owners of the new street railway system in Vera Cruz, are reported to be considering constructing a similar system in the city of Tampico, including the building of an interurban line to various towns in that section.

Sewers.

Items Arranged Alphabetically by States.

Mobile, Ala.—Wright Smith, C. E., is preparing plans and specifications for storm drainage for the north and western part of the city. The estimated cost is about $500,000.

Selma, Ala.—Council has passed resolution to borrow $4,000 for extending trunk sewer across the southern part of the city.

Corona, Cal.—City Council is considering installing a sewer system.

Los Angeles, Cal.—City Council has approved plans of the City Engineer for the West Boyle Heights sewer system. The sewer will be about 8,100 ft. long.

San Diego, Cal.—Council has passed ordinance authorizing Board of Public Works to construct the general enlargement and extension of the sewer system by day labor and also to purchase in open market all fittings necessary with the exception of pipe. The estimated cost of the work to be done is $52,894; of this sum $11,000 has been appropriated for pipe.

San Francisco, Cal.—Board of Supervisors have ordered the construction of the southerly section of the Eastern Potrero intercepting sewer in accordance with the plan of the City Engineer. The estimated cost is $140,000. M. Manson is City Engineer.

Bridgeport, Conn.—Council Committee on Sewers has asked appropriation of $78,000 for sewer work this year. Of this amount $44,000 is for special sewer construction.

Meriden, Conn.—An appropriation of $13,500 has been recommended for new sewer construction this year.

Des Moines, Ia.—James Horrabin at $1.79 per foot and the Turner Improvement Co. at $1.89 per foot, were the only bidders for constructing the West 7th St. sewer.

Davenport, Ia.—Hearing was held by the Board of Public Improvements on Jan. 6 for objections to the proposed 6th ward sewer system. City Engineer, Wallace Treichler, estimates the cost at $42,500.

Aurora, Ill.—City Engineer Tarble has about completed plans for 30,000 ft. of sewer extension in the 3d and 4th wards.

Topeka, Kan.—City Engineer has surveys under way for the proposed new Kenwood sewer to drain the Kenwood addition to the city east of Potwin. The district will be of considerable size.

Louisville, Ky.—Board of Public Works is having plans prepared for considerable amount of sewer work for this year.

St. Louis, Mo.—Plans have been made by Sewer Commissioner Fardwell for sewers aggregating an expenditure of $2,500,000 to be constructed this year. Other plans involving a larger expenditure will be completed in the next six weeks. Ordinances authorizing the constructing of sewers costing more than $5,000,000 probably will be introduced into the council within the next two months. The principal items are for the construction of 7,000 ft. of 10-ft. storm water sewer for the River Des Peres and the construction of about six miles of sewer in the Harlem drainage area.

St. Joseph, Mo.—Board of Public Works has plans underway for an expenditure of $250,000 for building main sewers and culverts and in repairing main sewers and bridges. W. K. Seitz, Assistant Engineer, is in charge of the plans. Bids for some of the smaller work have already been asked.

Springfield, Mo.—Mayor Ernst is advocating the expenditure of $150,000 for installing storm sewers.

Reidsville, N. C.—Election will probably be held to vote on the issuance of bonds for installing sewer system and street improvements. R. S. Montgomery is Mayor.

College Hill (P. O., Cincinnati), O.—City is to sell a $25,000 bond issue on Feb. 8 for construction of sanitary sewers. F. B. Strong is Village Clerk.

Akron, O.—Board of Public Works is to construct storm water sewer along the railroad tracks from the Union Depot to the Old Forge.

Canton, O.—L. D. Bird, at $3,837, was low bidder for constructing the Landen St. storm sewer.

Cincinnati, O.—City Engineer Stadmiller is to submit plans for a sewer to be built west of Torrence Road and [illegible] from the existing sewer in West Fork Creek, Colerain Av., to the north corporation line of Mt. Airy.

Collinsville, Okla.—City is taking steps to secure the construction of a sanitary sewer system.

New Castle, Del.—Special Street Sewer Commission, A. N. Hizar, Chairman, is considering calling a special election for the purpose of ascertaining the sentiment of the people relative to bonding the city for the proposed new sewers and paved streets.

Chattanooga, Tenn.—Bill is to come before the State Legislature to authorize the city to issue $100,000 of bonds for sewer work.

Arlington, Tex.—City has voted to issue $25,000 of bonds for sewer construction.

Bryan, Tex.—City Council has been asked to arrange for a bond election for the purpose of securing a sewer system and for improving the water and light plants. J. T. Maloney is Mayor.

Winchester, Va.—An election was held Jan. 8 to vote on installing a sewer system. W. H. Baker is President of the City Council.

Tacoma, Wash.—Plans are under way by Frank L. Davis, City Engineer, for a storm water sewer system, preliminary estimates of which have been ordered by the City Council. The plan calls for large trunk sewers which will cost approximately $300,000. It is expected that money for their construction will be voted at a bond election, to be held in the spring. One of the largest of the proposed trunk lines will be a 5-ft. brick sewer in T St.

Kenosha, Wis.—City Engineer has completed plans for a trunk sewer.

New Toronto, Ont., Canada.—T. Aird Murray, Consulting Engineer, Toronto, Ont., is preparing plans for a sewer system for this place.

Water Supply.

Items Arranged Alphabetically by States.

Danville, Ark.—The Danville Electric Light & Water Co., recently incorporated with a capital stock of $10,000, is to establish a water works plant and also is to furnish light and power for this city. D. F. Montgomery, C. T. Meadows and A. M. Fells are the incorporators.

Eldorado, Ark.—The Eldorado Light & Water Co. has been incorporated with a capital stock of $50,000. John B. Holmes, S. B. Morgan and J. H. Hudson are the incorporators.

San Diego, Cal.—Board of Public Works have been asked to lay water mains in National Av. to 10th St.

Perry, Ia.—The local water works are to be rebuilt at a cost of about $15,000.

Downey, Cal.—The Downey Light, Water & Power Co. has been incorporated with a capital stock of $75,000. The incorporators are J. R. Gordon, Florence Gordon, H. W. Hagerman, A. L. Darby and J. F. Ardis.

Arvada, Colo.—The town is considering securing a water system. Richard Russell is Mayor.

Bloomington, Ill.—The Board of Local Improvements has adopted estimates for installing a water main in South Madison St.

Cerro Gordo, Ill.—City is considering installing water works.

Emporia, Kan.—City Council has decided to add 20 more wells to its water system. Alva Smith is City Engineer.

St. Matthews, Ky.—The St. Matthews Water Supply Co. has been incorporated with a capital stock of $[illegible]. The incorporators are Henry [illegible], Alex. Stengle and Dudley Gregory.

Ann Arbor, Mich.—Extensive improvements are to be made to the water works by the Ann Arbor Water Co.

Elmore, Minn.—City has voted $[illegible] of bonds for the construction of a new water works system.

Holly Beach, N. J.—City Council has granted franchise to the Holly Beach, Wildwood & North Wildwood Water Co. to erect a water plant.

Bartlesville, Okla.—Special election will be called shortly to vote on issuing bonds to enable the city to purchase the present water works plant.

Kiowa, Okla.—City has voted $[illegible] of bonds for installing water works.

Tulsa, Okla.—City Council has authorized a special election to vote on the issuance of $225,000 of bonds for building a pipe line to Collinsville, [illegible] for [illegible] [illegible] separate the water system [illegible].

Lebanon, Pa.—Work [illegible] on enlarging the capacity of Dam No. 1 at the South Mountain city reservoir. An appropriation of [illegible] has been made for the work.

Pottsville, Pa.—[illegible] Water Co. is planning to erect a large [illegible] reservoir.

Cleveland, Tenn.—The city [illegible] is considering purchasing the local water works for $[illegible].

Chattanooga, Tenn.—Ordinance has been passed by the Council to issue bonds for $300,000 for the purpose of construction of a water works plant.

Anson, Tex.—Plans are being prepared for water works for this town to cost about $25,000. The O'Neil Engineering Co., Dallas, Tex., are engineers.

Haskell, Tex.—City has voted $[illegible] of bonds for water works and street improvement.

Orange, Va.—Plans for a proposed new water works system for this city to cost $[illegible] are being prepared by D. G. [illegible], Consulting Engineer, Baltimore, Md.

Brewster, Wash.—A new company composed of D. S. Gamble, Hattie Gamble, F. L. Clifford, C. V. Rice, is being formed to purchase the holdings of the Brewster Water & Power Co. which [illegible] the [illegible] system.

TRADE NOTES.

The Marquette Cement Manufacturing Co., which has its works at La Salle, Ill., is to add machinery and equipment which will increase its total investment to more than $2,000,000. The improvements will increase the output 50 per cent over that of last year, bringing the total to 4,000 bbls. of Portland cement daily. The works were started twelve years ago with an output of 400 bbls. a day. The cement is controlled and directed by William and Theodore Dickinson of Chicago, pioneers in the cement industry. The increased output is provided for because of the anticipation of an increased consumption of cement, everything indicating a return of prosperity to this branch of the building trade, as cement now is being used largely in every building project.

The Leadite Co. has removed to its new offices in the Land Title Bldg., Broad and Chestnut Sts., Philadelphia, Pa.

Announcement has been made that hereafter the department of Track Devices of the Quincy, Manchester, Sargent Co. of New York and Chicago will be operated under the old and familiar name of The Q & C Company.

The New York offices of [illegible] Co. have been moved from 68 Broad St. to [illegible] Church St.

Ernst Wiener Co. has [illegible] its San Francisco office from [illegible] Bldg. to [illegible] Second St.

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GAS PRODUCER AND GAS ENGINE ELECTRIC LIGHTING PLANT.

Milwaukee, Wis., Jan. 6, 1909.

Sealed proposals will be received at this office until Wednesday, Feb. 17, 1909, at 10:30 o'clock a. m., for furnishing and erecting complete in running order ready for use, in buildings and on foundations to be furnished by the city of Milwaukee, all the machinery and appurtenances thereto, necessary to make a complete installation of a gas producer and a gas engine electric lighting plant, said plant to be located on blocks 70 and 95, on the corner of Walker and Davidson streets, in the Fifth ward of the city of Milwaukee, according to plans and specifications (dated Dec. 24, 1908) on file in this office.

Work to be completed within ten months from the date of the award of the contract, failing in which the contractor shall pay to the city of Milwaukee as liquidated damages the sum of $750 per day for each and every day's delay in completing the work.

Bonds to accompany bids required in the penal sum of $45,000, or in lieu thereof the bidder may deposit with the board of public works the sum of $22,500 in money or certified bank check.

In case bonds are submitted with bids, local bondsmen or a surety company authorized to do business in the state of Wisconsin will be required.

All moneys deposited will be returned to unsuccessful bidders on award of contract and to successful bidder when contract is entered into.

Plans and specifications will be furnished to prospective bidders on the receipt of $25 as a guarantee for their safe return.

CHARLES J. POETSCH,
J. P. SHERER,
L. A. JANSEN,
A. J. GRUNDMAN,
Commissioners of Public Works.
AUGUST M. GAWIN, Comptroller.

SEWER SYSTEM.

Purcell, Okla.

The City of Purcell, Okla., will let contract for the construction of a system of sanitary sewers. Bids will be received up to Monday, January 25, 1909, at 4 o'clock p. m., and opened at 8 o'clock p. m. of same date. Plans and specifications can be seen in the City Engineer's office. The city reserves the right to reject any or all bids.

M. S. ROBERTSON, City Clerk.

WATER-WORKS.

Hugo, Oklahoma, Jan. 8th, 1909.

Notice is hereby given that the City Council of Hugo, Oklahoma, will, until 8 p. m., February 2d, 1909, receive bids at the City Clerk's office, to furnish materials, tools and labor for the construction of a water-works plant for Hugo, Oklahoma, according to plans and specifications on file with the City Clerk, and also in the office of Hiram Phillips, St. Louis, Missouri.

The magnitude of the work to be done is about as follows:

One brick Power House.
One 3-million gallon concrete reservoir.
Two 150 H. P. tubular boilers.
Two 2-million gallons pumps, each.
Two 800 cu. ft. Air Compressors each.
4,185 ft. 14" cast iron pipe.
1,790 ft. 12" cast iron pipe.
1,610 ft. 10" cast iron pipe.
5,510 ft. 8" cast iron pipe.
55,485 ft. 6" cast iron pipe.
14,365 ft. 4" cast iron pipe.
135 Fire Hydrants.
Two 14" valves.
One 12" valve.
One 10" valve.
Seven 8" valves.
Forty-five 6" valves.
Twenty-two 4" valves.
700 Water Meters.
Material for 700 House Connections.

Bids must be made upon blanks furnished by City Clerk, which will be furnished upon application.

A set of blue prints and specifications will be furnished by the Council upon receipt of $3.00, which will be refunded upon receipt of bid and return of plans and specifications.

The Council reserves the right to reject any or all bids.

A deposit of 5% of amount of bid must accompany bid.

W. L. GIBBS.
Attest: Acting Mayor.
W. T. ECHOLS, Clerk.

CONCRETE SEWER.

Louisville, Ky.

Sealed proposals for the construction of a sewer known as the Southern Outfall Sewer, Section "F," Contract No. 20, of the Comprehensive System of Sewerage for the City of Louisville, Ky., will be received at the office of the Commissioners of Sewerage until 12 o'clock noon, January 22, 1909.

The work will consist mainly of building a reinforced concrete sewer 12 feet in diameter, about 2,440 feet long, including about 3,630 cubic yards of concrete and 236,000 pounds of steel.

Plans and specifications may be seen at the office of the Commissioners and at the office of Harrison P. Eddy, Consulting Engineer, 14 Beacon St., Boston, Mass.

Sealed bids should be endorsed "Proposal for Section 'F,' Southern Outfall Sewer," and addressed to the Commissioners of Sewerage, Equitable Building, Louisville, Ky. Each bid must be accompanied by a certified check for at least seven per cent (7%) of the total amount of the bid, or a "Bidder's Bond," as described in the form of proposal.

P. L. ATHERTON, Chairman.
CHAS. P. WEAVER, Secretary and Treasurer.
J. B. F. BREED, Chief Engineer.

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Expert Designer and Inspector of Bridges
Citizens Building Cleveland Ohio

WATER WORKS, ELECTRIC-LIGHTING AND SEWERAGE SYSTEM.

East Point, Ga.

Sealed proposals will be received by the Mayor and City Council of East Point, Ga., until 3.30 p. m. January 19, 1909, for furnishing and erecting at East Point, Ga., the following material

One 150-horse-power boiler 72x18 and stack.

Two 750,000-gallon capacity in 24 hours compound duplex pumps.

One boiler-feed pump.

One 125-horse-power direct-connected four-valve engine.

One air compressor and receiver

Seventy-five hydrants.

Forty-nine flush tanks.

Seven hundred tons cast-iron pipe and specials.

Excavating and building reservoir 75 feet in diameter and 10 feet deep

Building pumping station

One 100-kilowatt alternating generator, direct connected; revolutions, 200 per minute.

Twenty-five arc lamps and regulator

Pole lines.

Switchboards and feeder panels, including all instruments.

Building about 12 miles sewerage.

Digging one or two 6-inch and 8-inch wells.

The city reserves the right to reject any or all proposals.

Specifications can be had by applying to E. H. Davis, engineer, Griffin, Ga.

This December 15, 1908.

J. C. McKENZIE.
Mayor of Town of East Point.
S. M. McCOWELL.
Clerk of Town of East Point

DREDGE WORK.

Logan, Iowa.

Bids will be received by the Auditor of Harrison County at Logan, Iowa, up to 10 a. m. February 10th, for the dredge work on the Boyer River Improvement Ditch, in said county. The ditch is 6.38 miles long and the excavation amounts to 311,000 cubic yards. Construction work to commence on or before April 15, 1909, and be completed by January 1, 1910. For copies of specifications, contract and other information apply to

G. W. ATKINS, Auditor
Logan, Iowa
Or to SETH DEAN, Cons. Engineer,
Missouri Valley, Iowa.

OFFICE OF THE CONSTRUCTING QUARTERMASTER, Fort Crook, Nebraska, December 21, 1908. Sealed proposals, in triplicate, will be received at this office until 11 o'clock a. m., January 21, 1909, and then opened, for constructing one brick stable and one brick bakery, and for installing plumbing, steam heating, electric wiring and electric lighting fixtures in buildings specified. Plans and specifications may be seen by intending bidders at the offices of the Chief Quartermaster, Department of Missouri, Omaha, Nebraska; Department of the Colorado, Denver, Colorado; Department of the Lakes, Chicago, Illinois, Department of Dakota, St. Paul, Minnesota, and at this office.

Necessary blank forms and full information furnished upon application here. A deposit of $10.00 to insure return, is required before plans are sent upon individual application. The United States reserves the right to reject any or all bids, or to accept any part of a bid that may be advantageous to the Government. Envelopes containing proposals must be endorsed "Proposals for Public Buildings," Etc., Fort Crook, Nebraska, and addressed to Capt. Joseph F. Gohn, Constructing Quartermaster.

WATER WORKS.

Daytona, Fla.

Sealed proposals will be received by the Board of Public Works of the City of Daytona, Florida, at the City Hall of said city, up to three o'clock p. m., of the twenty-fifth day of January, 1909, for furnishing materials and constructing a system of waterworks for said city.

There will be required approximately, the following:

1 000 tons cast-iron pipe
16 tons special castings
76 two-way fire hydrants
10 10-inch gate valves
20 8-inch gate valves.
60 6-inch gate valves.
3 8-inch check valves
1 pressure release valve

Gasoline engine and power pump of 1,100,000 capacity, with 100 pounds pressure.

Elevated steel tank and steel tower

7 4-inch artesian wells.

Concrete foundations, pumping-plant building and concrete receiving well

Installing system.

Bids will be received for furnishing any of the above materials and work or for constructing the works complete. A certified check equal to 5 per cent of the amount of the bid must accompany each bid. Checks to be made payable to the Chairman of the Board of Public Works of the City of Daytona, Florida.

The right is reserved by the Board to reject any or all bids should it be deemed for the best interests of the city to do so.

C. M. ROGERS.
Engineer of the Board of Public Works.

PAVING.

Pensacola, Florida

Sealed proposals for the construction of concrete sidewalks in the City of Pensacola, Florida, will be received by the Board of Public Works at the City Hall up to 12 o'clock noon of the 18th day of January, A. D. 1909, proposals to be addressed to L. G. Aymard, Clerk of the Board of Public Works, and endorsed "Proposals for Construction of Concrete Sidewalks."

The work contemplated consists of approximately 634,000 square feet of concrete sidewalks. Specifications and blank form of proposal and contract can be obtained from the office of the City Engineer, Room No. 203, City Hall.

The right is reserved to reject any and all bids.

Each proposal is to be accompanied by a certified check for $500.00, payable to the City of Pensacola.

LEE DANIELL.
Chairman Board of Public Works.
L. EARLE THORNTON, City Engineer.

BUILDING MATERIALS.

Chicago, Ill.

The Alling Construction Co. are the low bidders for the Infirmary for the County of Cook to be built in Oak Forest, Ill. This concern is in the market for labor and material for about 1,[illegible] square feet of reinforced concrete floors, 10,[illegible] brick, 30,000 barrels of cement, and also steam fitting, plumbing, heating, electric wiring, smokestack, concrete blocks, power plant, ornamental and miscellaneous iron work, plastering, painting, slate roofing, sheet metal work, glazing and all other branches of work which go to make a complete and finished building.

ALLING CONSTRUCTION CO.
7[illegible] Madison St., Chicago, Ill.

TUNNEL.

Shamokin, Pa.

Bids will be received by the Mineral Railroad & Mining Company for the driving of a tunnel from the No. 4 seam to the No. [illegible] seam north in No. 1 slope level at the Cameron colliery. Total distance about 600 feet, to be driven by machine work. The company to furnish steam and compressor. Specifications can be seen at the office of the superintendent, Shamokin, Pa. All bids to be submitted by the [illegible] of January, 1909. The superintendent reserves the right to reject any or all bids.

I. A. RHOADS, Superintendent.

COURT HOUSE.

Omaha, Neb.

Notice is hereby given that the Board of County Commissioners for the County of Douglas and State of Nebraska will receive bids for the construction of a Court House for Douglas County, according to the plans and specifications on file in the office of the County Clerk of said county. Bids will be addressed to D. M. Haverly, County Clerk, enclosed and sealed in properly endorsed envelopes, and filed with him not later than March 1, 1909, at 12 o'clock noon, at which time said bids will be opened.

Copies of the plans and specifications can be obtained from the undersigned or from the Architect, John Latenser, 632 Bee Building, Omaha, upon application. A certified check for $50.00 must accompany all applications for plans as a guarantee that bids will be submitted on the same, the check to be returned when the bids are opened.

All bids must be submitted on blank proposals, which will be furnished on application by the County Clerk or John Latenser, Architect.

Samples of stone and granite upon which bids are based must accompany each bid.

Each bidder must submit with his proposal a certified check in a sum equal to 3 per cent of such proposal, the same to be drawn in favor of the Board of County Commissioners of Douglas County, Nebraska.

The Board of County Commissioners reserves the right to reject any and all bids.

D. M. HAVERLY
County Clerk, Omaha, Neb.

PAVING.

Huntsville, Ala.

Sealed bids wanted for paving Clinton street in the City of Huntsville, Alabama, with Granitoid, [illegible] Brick, Asphalt or Mineral Rubber Asphalt. Bids to be received till the [illegible] day of January, 1909. This city reserves the right to reject any or all bids. Work to be done in accordance with specifications now on file in the office of the City Clerk in the City of Huntsville, Alabama. Payment as work progresses to be made in cash or bonds. Certified checks of $1[illegible] to accompany bids. Address Mayor, Huntsville, Ala.

R. F. SMITH, Mayor.

MONUMENT.

Rockford, Ill.

The Illinois Andersonville Monument Commission invites proposals for design, and for the erection of a monument in accordance with said design at Andersonville, Georgia. Full information as to proposed monument will be mailed on application to LEWIS F. LAKE, Secretary of the Commission, at Rockford, Ill.

List of Contractors' Supplies.

If you wish catalogs of the leading manufacturers send us a postal card giving your address and business, and the list numbers, as shown below, of articles of which you want catalogs.

This will save you the trouble of writing a large number of letters. Should you later on have correspondence direct with the manufacturers, we shall appreciate it if you will state in your letters that you are indebted to this paper for the introduction. Such a statement will be mutually beneficial.

Air compressors. See 94.
2 Asbestos.
4 Asphalt.
6 Asphalt plants.
7 Asphalt tools.
8 Augurs, pneumatic.

10 Ballast spreaders.
12 Ballast unloaders.
13 Barrows, concrete.
14 Bearings, ball and roller.
16 Bearings, self-oiling.
18 Bellows.
Belt conveyors. See103
20 Belt dressing.
22 Belting, canvas.
24 Belting, chain.
26 Belting, leather.
28 Belting, rubber.
Benders, rail. See 404
29 Benders, steel reinforcing rod.
30 Blacksmiths' tools.
31 Blasting batteries.
32 Block machines, cement and concrete.
33 Blocks, tackle.
Blowers. See 180.
34 Blast hole loaders.
35 Bolts and nuts.
36 Blue print machines.
37 Boots, engineers' and contractors'.
38 Boilers.
39 Boiler covering.
Bonds, contractors' surety. See 98.
40 Brakes, air.
41 Bridge railings.
42 Brick, building.
44 Brick, paving.
45 Brick machines.
46 Bridges, steel.
47 Bridges, concrete.
48 Buckets, clam shell.
49 Buckets, concrete.
50 Buckets, dumping.
52 Buckets, orange peel.
53 Brooms, street cleaning.

58 Cabinets, filing.
59 Calculating machines.
Cables. See 430.
60 Cableways.
61 Caissons.
62 Cars, ballast.
63 Cars, concrete.
64 Cars, dump.
66 Cars, flat.
68 Cars, hand.
69 Cars, mining.
70 Carts. See also 520.
71 Carts, street, hand.
72 Carts, concrete.
73 Castings, brass.
74 Castings, iron.
76 Castings, steel.
Cement block machines. See 32.
78 Cement finishing tools
80 Cement pipe molds.
81 Cement testing machines.
82 Cement walk tools.
84 Cement, natural.
86 Cement, Portland.
87 Centers and forms for concrete.
88 Chains, common.
90 Chains, sprocket.
91 Channelers.
Cleaners, flue. See 189
92 Clocks, time.
93 Chimneys.
94 Compressors, air.
95 Conduit, bituminous fiber.
Concrete reinforcing. See 474.
Conduit, vitrified. See 142.
96 Concrete fence post molds.
97 Computing machines.
98 Contractors' bonds.
99 Concrete form clamps.
Concrete form holders See 195.
100 Contractors' supplies.
101 Coal handling machinery.
102 Conveying machinery.
103 Conveyors, belt.
104 Cranes.
106 Cranes, locomotive.
108 Cranes, traveling.
110 Creosoting.
112 Crossings, railway.
114 Crushers, rock.
115 Culverts, concrete.
116 Culverts, vitrified pipe
117 Culverts, metal.
118 Curbs, street.

119 Dams, concrete.
120 Derricks and fittings.
121 Draftsmens' supplies.
122 Ditching machinery.
123 Dipper teeth.
124 Dredges.
126 Drill sharpeners.
Drills, air. See 136.
128 Drills, core.
130 Drills, diamond.
131 Drills, electric.
132 Drills, pneumatic plug.
134 Drills, ratchet.
136 Drills, rock.
138 Drills, well.
139 Dryers.
140 Dynamite.
Dust layers. See 419.
142 Ducts, vitrified.
Dump wagons. See520
144 Dynamos.

Economizers, fuel. See 198.
150 Electric machinery.
Electric motors. See 324.
152 Elevators, bucket.
154 Engineers' instruments.
156 Engines.
158 Engines, gas.
160 Engines, gasoline.
162 Engines, hoisting.
164 Engines, steam.
166 Engines, traction.
167 Expansion bolts.
168 Expanded metal.
169 Expanders, tube.
170 Exploders.
172 Explosives.

178 Feed water heaters.
180 Fans or blowers.
181 Filing cases.
182 Felt.
183 Fillers for brick and stone pavement.
184 Fence and railing.
185 Fireproofing materials.
186 Filters, water.
187 Fireproof doors, partitions.
188 Flanges, steel.
189 Flue cleaners.
190 Flue lining.
192 Flush tanks.
194 Forges, blacksmith.
195 Forms for concrete work.
Forms and centers. See 87.
196 Frogs and switches.
198 Fuel economizers.
Fuse. See 170.

204 Gas machinery.
206 Gages, steam.
208 Gages, water.
210 Garbage furnaces.
212 Gates and valves.
214 Gears and pinions.
216 Governors, engine.
218 Governors, water wheel.
220 Graders, elevating.
221 Grain handling machinery.
222 Gaskets.
223 Grinding machinery.
224 Grubbers.
225 Grout mixers and injectors.

228 Hammers, pneumatic.
230 Hangers, joist.
232 Harness.
233 Heating and ventilating machinery.
234 Hoists, air.
236 Hoists, chain, differential.
238 Hoists, electric.
240 Hoists, gasoline.
242 Hoists, horse-whim.
244 Hoists, steam.
246 Horse feed-bags.
247 Hose, air and steam.
248 Hose, water.
249 Hose carts.
250 Hydrants.
251 Hydraulic machinery.

258 Ice and refrigerating machinery.
260 Injectors.
261 Insulated wire.
262 Iron.
264 Iron, corrugated.
266 Iron, sheet.
267 Insurance, laborers'.

270 Jacks, hydraulic
272 Jacks, screw.
274 Jacks, track.
Jacks, trench. See 502
276 Judson powder.

278 Kilns.

280 Laborers supplied.
281 Lamps, acetylene.
Lamps, contractors'. See 286.
282 Lamp posts.
283 Lamps, electric.
284 Lathe, metal.
285 Lead.
286 Lights, contractors'.
287 Lead furnaces.
288 Lime.
289 Lights, vault.
290 Locomotives dinkey.
292 Locomotives, electric.
294 Locomotives, gasoline
296 Locomotives, geared.
298 Locomotives, steam.
299 Logging outfits.
300 Lubricants.
302 Lumber, creosoted.

308 Machinery, tile making.
310 Machine tools.
312 Manganese steel.
313 Mattocks.
314 Manhole covers.
315 Metaline.
316 Meters, water.
318 Mineral wool.
319 Mining machinery.
320 Mixers, concrete.
322 Motors, compressed air.
324 Motors, electric.
326 Motors, water.

330 Nickel steel.
332 Nuts and nut locks.

333 Office appliances and furniture.
Oil. See 419.
334 Oilless Bearings.
336 Ore handling machinery.

337 Pavements.
338 Paving materials.
339 Paving tools.
340 Packing.
341 Painting machines.
342 Paints.
343 Paving blocks, wood.
344 Paving blocks, stone.
Paving bricks. See 44.
345 Paper, building.
346 Paper, blueprint, drawing, tracing.
348 Picks.
350 Pile drivers.
352 Pile driver jets.
353 Pile shoes and rings.
354 Piles, concrete.
356 Piles, interlocking, steel.
358 Piles, creosoted.
359 Pipe fittings.
360 Pipe covering.
362 Pipe, cast iron.
364 Pipe, cement.
366 Pipe, lead.
367 Pipe, reinforced concrete.
368 Pipe, riveted steel.
370 Pipe, vitrified sewer.
371 Pipe, wooden.
372 Pipe, wrought iron.
374 Pipe cutting machine.
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380 Portable railways.
381 Pulverizers.
382 Powder, black.
383 Prism glass.
384 Pulleys.
385 Pumps, air lift.
386 Pumps, diaphragm.
387 Pumps, centrifugal.
388 Pumps, electric.
389 Pumps, contractors'.
392 Pumps, sand.
393 Pumps, sewage.
394 Pumps, steam.
396 Pumps, trench.
397 Pumps, windmill.
398 Punches, hydraulic.

400 Quarry bars.
402 Quarry machinery.

404 Rail benders.
405 Rail joints and fastenings.
406 Railroad signals.
408 Railways, industrial.
410 Rails, new.
412 Rails, second hand.
413 Railway track layers.
414 Rammers, pneumatic.
415 Recording instruments.
416 Riveters, pneumatic.
417 Road dust preventives.
418 Road machinery.
Rock crushers. See114
419 Road oil.
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424 Rollers, steam.
425 Roofers' supplies.
426 Roofing.
427 Rope drive.
428 Rope, manila.
430 Rope, wire.

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439 Sawmill machinery.
440 Saw mills, portable.
441 Scales.
442 Scarifiers for macadam.
444 Scrapers, drag.
446 Scrapers, road.
Scrapers, wheel. See 528.
447 Scrapers, street.
448 Screens, rotary.
150 Second hand outfits.
452 Sewage disposal.
Sewer braces. See 502
454 Sewer cleaners.
455 Sewer traps.
Sewer pipe. See 370.
457 Shafting.
458 Sheaves.
460 Shovels, hand.
461 Skylights.
462 Skips.
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468 Standpipes.
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Street carts. See 71.
479 Street sweepers and cleaners.
480 Stump pullers.
481 Street flushers.
Street scrapers. See 447.
482 Switches.

486 Tanks, gas and oil.
488 Tanks, septic.
490 Tanks, water.
491 Tapes, engineers'.
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492 Tar.
493 Telegraph and telephone line equipment.
494 Tents.
495 Tie plates.
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499 Track tools.
500 Tracing cloth.
Tramways, wire rope. See 60.
501 Track materials, railway.
502 Trench braces.
504 Trench machines.
505 Turnbuckles.
506 Turntables.
507 Turbines (water wheels).
508 Turbines, steam.
509 Twisted steel.

510 Valves, steam.
512 Valves, water.
513 Vault lights.
514 Ventilators.
515 Ventilating apparatus.

518 Wagon loaders.
520 Wagons, dump.
522 Waterproofing.
524 Water softeners.
525 Waterworks machinery and supplies.
Well drills. See 138.
526 Wheelbarrows.
528 Wheel scrapers.
529 Wheels, car.
530 Windmills.
531 Winches.
532 Wire cloth.
534 Wire glass.
Wire rope. See 430.
Wood block pavement. See 343.
538 Wood preservatives.

The above is only a partial list of the headings in our Card Index. No matter what you want, TELL US and we will put you in prompt communication with the leading manufacturers, dealers or contractors.

STREET PAVING.

Olympia Washington

Bids will be received by the City of Olympia, Wash., until 5 p. m., Feb 1, 1909 for constructing about 6,000 sq yds of vitrified brick or creosoted wood block pavement Work to begin May 1, 1909

JAMES R DERER, City Clerk

PUMP.

Muskogee Okla

The City of Muskogee, Oklahoma, will receive bids for a five (5) million gallon centrifugal pump. Specifications will be sent on application to

L. B. KINSEY, City Engineer

PROPOSALS FOR CONSTRUCTION OF barracks and quarters, and plumbing and heating and electric wiring same. War Department, office of the Constructing Quartermaster, New London, Conn., November 28, 1908. Sealed proposals for constructing one double barrack one single barrack, two field officers' quarters, one four-set officers' quarters, two lieutenants' quarters, three double non-commissioned officers quarters, and one double firemen's quarters, at Fort Terry (Plum Island), New York, and two double barracks, two field officers' quarters, four lieutenants' quarters two double non-commissioned officers' quarters, and two double firemen's quarters, at Fort H G. Wright (Fisher's Island), New York, and for plumbing, electric wiring and installing heating plants in same will be received here until 10 a m., Feb. 10, 1909, and then opened Proposals are desired for brick construction of all buildings and for reinforced concrete construction on bidders plans of barracks and non-commissioned officers' and firemen's quarters. Information furnished on application. Envelopes containing proposals should be endorsed "Proposals for Public Buildings." and addressed: "R. M Schofield Major, Q. M., Constructing Quartermaster, New London, Conn."

POWER PUMP.

Richland Center Wis

Sealed bids will be received by Reuben Sutton, City Clerk until 8:00 p m. February 2 1909 for the furnishing of a 400-gallon triplex power pump. Certified check 5 per cent of bid Specifications and blank proposals can be had from

W G KIRCHOFFER Engineer
Madison Wis

TANK.

Wellington Kan

The City of Wellington will erect one water tank 110 feet in height and 150,000 gallons capacity. Bids to be received until the 18th of January.

CHAS. L COVELL.
Supt Water Works and Electric Lights

U S. ENGINEER OFFICE WILMINGTON N. C., DECEMBER 30, 1908 Sealed proposals for constructing steel draw-span highway bridge with pile and concrete foundations, on Core Creek, near Beaufort, N C., will be received at this office until 12 o'clock noon, standard time, January 30, 1909, and then publicly opened. Information on application. EARL I. BROWN, Capt. Engrs.

KEY WEST, FLORIDA Sealed proposals in duplicate will be received by the undersigned until 11 a m., February 5 1909, and then publicly opened for furnishing a condenser, filter feed water heater, etc.; also for remodeling pumping and distilling plant at Key West Barracks, Fla. Plans and specifications on request. Proposals should be marked "Proposals for pumping plant" and addressed to CAPTAIN C. H. LANZA, Quartermaster, Key West, Florida.

COLLEGE BUILDING.

Ames Iowa

Sealed proposals will be received at the office of the Secretary of the Board of Trustees of the Iowa State College Ames Iowa until two o'clock p. m. January 25 1909 for the erection and completion of a two-story Annex for the Engineering Department plans and specifications for which may be seen at the office of the Secretary at the College and at the office of Proudfoot & Bird Architects No 627 Flynn Building Des Moines, Iowa

Bids will be received for the building complete except heating plumbing and electric work

Bond 50 per cent of the contract price certified check 2 per cent of the amount of the bid

The right is reserved to reject any or all bids and to waive defects in any bid if it be deemed to the interest of the College so to do

By order of the Board of Trustees
E W. STANTON Secretary

OFFICE CONSTRUCTING QUARTERMASTER FORT LEAVENWORTH KANSAS DECEMBER 28 1908 Sealed proposals in triplicate will be received here until 11:00 a. m. Central time January 27, 1909 and then opened for constructing a storehouse for Officers Property etc. at Fort Leavenworth Kansas Full information and blank forms of proposal furnished on application to this office. Plans and specifications may be seen at this office the office of Chief Quartermaster Department of the Missouri Omaha and Master Builders Exchange Kansas City Mo United States reserves the right to accept or reject any or all proposals or any part thereof Envelopes to be endorsed Proposals for Public Buildings and addressed to CAPTAIN WM D DAVIS Quartermaster

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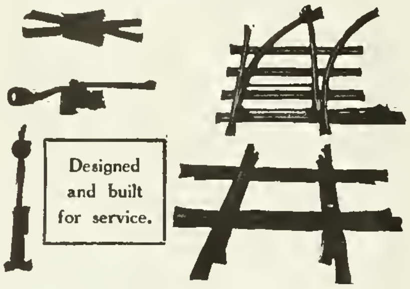
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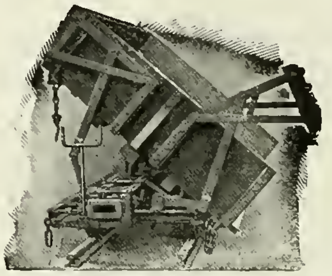

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Copy for regular advertising must be received not later than Friday preceding date of issue in which it is to appear. "Proposals," "Wants" and "For Sale" announcements can be inserted as late as Tuesday morning.

Entered as second-class matter, April 17, 1907, at the Post Office at Chicago, Illinois, under act of March 3d, 1879.

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Bonding New Concrete to Old; The Efficiency of Various Bonds and Joint Constructions.

Knowledge of the strength of the adhesion or bond of new concrete to old is of great importance to cement users. Though we speak glibly of monolithic concrete construction there are few pieces of concrete work of size on which concreting is prosecuted continuously day and night but in almost every case fresh concrete is joined each day to concrete that has set and hardened and there is a plane of greater or less weakness at the junction. Competent builders recognize this fact and so plan their day's work that these joints or planes of weakness come at places where they cause little or no injury. This plan avoids the difficulty; it needs to be met squarely.

It is not possible always to finish a unit or predetermined amount of concreting in a day and new concrete has to be joined to concrete already hard at places where planes of weakness are objectionable. It would be a great gain to be able to repair, say, a beam which has cracked through, without rebuilding the whole beam and perhaps the whole floor panel in which it comes. Floor surfaces and other finishes could often better be laid after the base had hardened were a trustworthy method of bonding new concrete to old at the command of the builder. These are some examples of the opportunities for utilizing a sure method of bonding new concrete to old. They cannot be met squarely by other means.

Is there a sure method of bonding new concrete to old? There are plenty of opinions as to this possibility, and there are a number of methods for which more or less success has been claimed. Recently a number of experimenters have undertaken to secure some positive and specific test data regarding these methods. In another column we give briefly the results of one of these experimental studies. They indicate several facts of interest, but before noting these facts it will be interesting to present briefly two previous test records that have been made public.

In 1907 Mr. Mesnager, a French engineer, tested the strength of butt joints in prisms of 1-2-4 concrete 2¾ ins. square and 13½ ins. long. A half length prism was molded first and after 7 or 30 days the prism was completed by adding fresh concrete onto one of the 2¾x2¾ in. ends without marking or scoring the old cement. The end to which the fresh cement was added was in some cases merely well wetted and in other cases it was washed with neat cement grout. The prisms were broken at the joints by flexure. The general conclusions from these tests were: (1) A grout wash is an aid in bonding new concrete to old, and, (2) whether or not grout is used an excessive tamping of the new concrete near the joint adds appreciably to the strength of the bond. The second conclusion brought out a fact which, so far as we recall, had not previously been clearly stated.

In 1908, Mr. Raymond B. Perry, in thesis work at the Case School of Applied Science, repeated Mesnager's tests, using, however, 1-2 mortar prisms instead of 1-2-4 concrete. Various other methods of bonding than those employed by Mesnager were also tested. Mr. Perry's conclusions were: (1) That the bond between new and old mortar or concrete, where the joint is smooth, is very slight. (2) That about one half the strength of the concrete is developed in a joint bonded (a) by roughening the old surface, (b) by applying a layer of cement paste, (c) by providing the old surface with a bonding groove. (3) That a large part of the strength of the concrete, perhaps as much as 90 per cent, is developed where the old surface is roughened and a layer of cement paste is applied. (4) That such a solution as Ransomite practically takes the place of the roughening.

In the tests described elsewhere in this issue, six kinds of joints were tested. One of them, the reinforced vertical joint, may be set aside as not representing truly the bond of concrete to concrete; to a less degree this criticism also applies to the dovetail joint. Limiting our consideration to those forms of joints whose strength depends on the degree of adhesion of concrete to concrete, it will be seen that the strongest form of joint tested was the scarf joint and that this form of joint was made somewhat stronger by etching the face of the scarf—on the concrete already set—with acid. Roughening the old concrete and covering the junction surface with cement paste did not, according to these tests, help much toward increasing the bond. In view of the very positive advantages gained by roughening and grout washing in both Mesnager's and Perry's tests these negative results must, we should imagine, be the result of some extraneous factor not observed in conducting the tests. The mechanical effect of etching with acid is much the same as that of tooling or roughening, yet it appears that etching helped the bond and tooling did not. The reason for the difference is not clear.

The notable feature of the tests made by Mr. Miller is, however, the remarkable strength of bond secured with the scarf joints. Writers on concrete construction generally warn us to use vertical joints and never scarf joints in breaking off for beam and slab work. Their reasons for this injunction are not, however, based on the belief that the vertical joint gives a stronger bond than the scarf joint, but that we cannot safely count on any bond with either form of joint and that this plane of weakness had best be so arranged that if separation occurs it will be easy and definite. It, however, [illegible] made which will show [illegible] they did it [illegible] be using vertical joints in breaking [illegible] beam and slab joints [illegible] ly over end supports? The answer [illegible] course there [illegible] are conclusive. They are not conclusive, for they are too few and they were made under one set of conditions.

We have not made this [illegible] to belittle the tests made by Mr. Miller; on the contrary we think his work has been valuable and suggestive [illegible] to encourage

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others who are in the position to do so to repeat his tests and put his results to the proof. If it is as simple a matter to bond one half of a beam to the other half as these tests indicate then a great many builders have been borrowing a lot of unnecessary trouble.

Annual Meeting of the Western Society of Engineers.

The 39th annual meeting and dinner of the Western Society of Engineers was held on Jan. 5. In some respects the event was more notable than any similar one ever held by the society. The retiring president had to report the completion and occupation of the society's new quarters, the largest and best arranged that it has ever possessed. The features of the meeting, however, were the addresses by Mr. Frank Trumbell, president Colorado Southern R. R., and by General Greenville M. Dodge. General Dodge's subject was "The Civil and Mechanical Engineers' Work in the West in an Early Day and During the Civil War," and his account of the location and construction of the Union Pacific Ry., of which he was chief engineer, was of high interest to the assembled engineers. One of the enjoyable events of the evening was the election of Mr. Octave Chanute, who has been a member of the society since its inception in 1869, an honorary member.

The three Octave Chanute medals for papers read during 1907 were awarded as follows: Civil engineering, to Prof. F. E. Turneaure for his paper on "Experimental Determination of Stresses in Web Plates and Stiffeners in Plate Girders"; mechanical engineering, to Messrs. Walter T. Ray and Henry Kreisinger for their paper on "The Nature of True Boiler Efficiency," and electrical engineering, to Mr. D. W. Roper for his paper on "A Few Unusual Burn-outs of Underground Cables."

The following officers were elected for 1909: President, Andrews Allen; vice presidents, P. Junkersfeld, O. P. Chamberlain and W. F. M. Goss; treasurer, Albert Reichmann.

At a meeting of the business agents of the various trade unions on Jan. 5 the following scale of wages for an 8-hour day for New York City for the ensuing year was decided upon: Boilermakers and iron shipbuilders, $5; carpenters and framers, $5; cabinetmakers, $4; cement and concrete masons, $5; electrical workers, $4.50; housesmiths, bridgemen, iron workers, $4.80; metallic and wood lathers, $4.50; marble cutters and settlers, $5; machinists of all descriptions, $4.50; plasterers, plain and ornamental, $5.50; plumbers and gasfitters, $5; painters, $4; decorators and gilders, $4.50; sheet metal workers, coppersmiths, tinsmiths, metal roofers, $4.50; stonecutters, $5; steam and hot-water fitters, hydraulic, pneumatic tube, etc., $5.

Concrete and Reinforced Concrete Section

Note:—This section is devoted to methods and cost of constructing concrete and reinforced concrete structures. It will cover the selection, testing and proportioning of concrete materials; laboratory tests of concrete; concrete mixing, transportation and placing; fabrication and placing of reinforcement, and form construction and erection. It will also contain articles on new and interesting developments in the design of reinforced concrete.

Cost of Reinforced Concrete Siphon for the Belle Fourche Irrigation Works.*

Careful records of cost of the Belle Fourche River Siphon, Belle Fourche Project, were kept during the construction period and an analysis of the cost is set forth in the following table, giving total and unit costs and quantities of the principal items. This work was advertised and proposals were opened April 16, 1907, but were rejected, and on June 10, 1907, proposals were again opened and rejected and the work was done by force account. Work was begun in August, 1907, and completed in October, 1908.

The Belle Fourche River Siphon is a concrete structure, 3,565 ft. long, with an internal diameter of 5 ft. The siphon operates under a maximum head of 65 ft. with an average head throughout the major portion of its length of nearly 5 ft.

The lowest unit bid on dry excavation and backfiling was $1.25 per cu. yd., and this work, as will be seen by the table, cost the United States $0.403 per cu. yd. The material consists of sandy loam, and was excavtaed with plows and Fresno scrapers. Labor and weather conditions were favorable, and the average rate of wages for labor per 8-hour day was $2.41.

The lowest unit bid received on trenching and backfilling was $3 per cu. yd., and it cost the United States $1.498 per cu. yd. The material consists of hard blue shale and was excavated with picks and shovels and handled with slip scrapers. Labor and weather conditions were favorable, and the average rate of wages for labor for 8-hour day was $2.44. The lowest unit bid re-

TABLE SHOWING COST OF THE BELLE FOURCHE RIVER SIPHON.

	Dry excavation 15,445 cu. yds.		Trenching and backfilling. 2,960 cu. yds.		Reinforced concrete 2,215 cu. yds., 3,565 lin. ft.		
Distribution of cost.	Total.	Unit.	Total.	Unit.	Total.	Unit cu. yds.	Unit lin. ft.
Preparatory expenses	$ 121.37	$0.008	$ 59.41	$0.020	$ 675.12	$0.300	$0.1893
Plant depreciation	238.52	0.015	109.17	0.037	967.41	0.430	0.273
Administration	271.00	0.018	146.00	0.049	2,298.04	1.030	0.6449
Engineering	357.86	0.023	478.91	0.162	632.17	0.290	0.178
Superintendence	458.81	0.030	198.34	0.067	939.86	0.420	0.264
Inspection	......	.....	......	.....	136.80	0.060	0.0384
Camp maintenance	343.62	0.022	153.77	0.052	719.53	0.320	0.202
Waterworks expense	248.56	0.016	42.96	0.015	621.29	0.280	0.1743
Blacksmith and carpenter shop expense	243.21	0.016	125.49	0.042	572.01	0.260	0.161
Labor—Crushing and screening gravel and sand	......	.....	......	.....	3,109.95	1.400	0.873
Hauling gravel and sand	......	.....	......	.....	1,102.10	0.500	0.310
Building, including cost of lumber in wood forms	......	.....	......	.....	1,861.02	0.840	0.523
Hauling lumber for forms	......	.....	......	.....	393.77	0.180	0.110
Erecting steel forms	......	.....	......	.....	1,044.33	0.470	0.294
Miscellaneous	......	.....	......	.....	721.51	0.320	0.202
Cleaning reinforcement	......	.....	......	.....	175.77	0.080	0.048
Bending and welding reinforcement	......	.....	......	.....	646.31	0.300	0.181
Mixing concrete	......	.....	......	.....	1.179.11	0.530	0.331
Placing concrete	......	.....	......	.....	909.04	0.420	0.255
Finishing and watering concrete	......	.....	......	.....	455.31	0 220	0.1273
Excavating	3,182.75	0.205	1,701.44	0.574	....	.....	......
Backfilling	665.79	0.044	676.86	0.229	....	.....	......
Pumping	......	.....	296.72	0.100	....	.....	......
Miscellaneous	59.06	0.004	35.60	0.012	....	.....	......
Materials—Cement	......	.....	......	.....	8,143.24	3.670	2.285
Steel	......	.....	......	.....	7,193.06	3.260	2.015
Hauling and storing cement	......	.....	......	.....	2,849.74	1.280	0.799
Hauling and placing steel	......	.....	......	.....	1,624.86	0.730	0.455
Miscellaneous	......	.....	51.41	0.017	663.68	0.300	0.1859
Supplies—Rent of steel centering	......	.....	......	.....	1,914.76	0.860	0.537
Miscellaneous	36.43	0.002	129.11	0.044	379.22	0.170	0.105
Corral expense	......	.....	231.07	0.078	....	.....	......
Pump, gasoline engine, etc.	......	.....	......	.....	....	.....	......
Totals	6.226.98	0.403	4.436.26	1.498	41,929.01	18.92	11.7611
Grand total							$52,592.25
Cofferdam							2,803.98
Operating equipment							346.33
Survey and design							1,916.95
Camp buildings							732.31
Total distributed cost							$58,418.82
Underdrainage							36.57
Placing pumps and valves							30.88
Cleaning and finishing							824.05
Grand total cost							$59,310.32

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*"Reclamation Record," January, 1909.

ceived for reinforced concrete was $13.50 per cu. yd., which covered labor and supplies only, as the reinforcing steel and cement were to be furnished by the United States. There were 301,950 lbs. of twisted lug bars used for reinforcement at a cost of $0.021 per lb., f. o. b. Belle Fourche, and the hauling, storing, and placing thereof cost $0.005 per lb. The cement cost $2.15 and $2.13 per barrel f. o. b. Belle Fourche, and the hauling and storing thereof cost $1.28 per cu. yd. of concrete. The haul of the cement was 16 miles, and that of the gravel was 1 mile. Blaw collapsible steel centers were used for forms. The concrete was machine mixed in the proportion of 1-2-4. Labor and weather conditions were favorable and the average rate of wages for labor per 8-hour day was $2.44. One foreman was employed at $225 and one at $100 per month for the whole work.

United States Steel sheet piling and sacks of sand were used for constructing the coffer dam. The specifications under which the work was advertised provided for the payment of $5,000 in a lump sum for this work. The actual cost to the United States was $2,830.98.

The total cost of the structure as distributed in the table is $58,118.82. There were expended $36.57 for underdrainage, $30.88 for placing pumps and valves, and $821.05 for cleaning and finishing work that were not distributed to the subdivisions shown in the table, making the grand total cost of the structure, $59,310.32.

The effect of temperature in the setting of cement is being tested by Mr. H. L. Sherman for the Aberthaw Construction Co., and the results so far obtained have recently been made public. The tests are being carried on at the Quincy Market Cold Storage Warehouse in Boston, where experiments through a wide range of temperature are possible. The results so far are as follows:

Temp. of Air and Materials. Fahr.	Initial set min.	Final set. hrs.-mins.	Mixture.	Av. tens. str. lbs. per sq. in. 24 hrs.	7 days.	28 days.
72 ……	45	3-50	Neat	290	457	413
72 ……	..	.	1-3	...	168	168
41° ……	45	8	Neat	29	511	583
.. ……	..	.	1-3	..	189	221
34 ……	45	8	Neat	17	417	508
.. ……	.		1-3	...	127	202
34 (room 7° F.) Froze solid in 10 mins. Cement soft on melting; no set.						
24 hrs. in 7° F. and 24 hrs. in 72° F....			Neat	..	75	...
7 days in 7° F. and 24 hrs. in 72° F., no strength, owing to cracks.						
7 days in 7° F. and 7 days in 72° F....				28		
7 days in 7° F. and 24 hrs. in 72 ……			1-3		29	
7 days in 7° F. and 7 days in 72 ……			.	.	28	

The best daily record of excavation on the Isthmian Canal for steam shovels since American occupation was made on Dec. 18, when 50 shovels in the Central Division excavated 70,687 cu. yds., an average of 1,402 cu. yds. per shovel and 175 cu. yds. per hour.

Tests of Strength of Concrete Joints*.

BY JOSHUA L. MILLER

Every engineer, contractor and foreman has his own methods for joining new concrete to old. For the purpose of determining the comparative strengths of these different joints, a series of tests were undertaken at the laboratories of Lafayette College, and the results are given here. The following kinds of joints were tested: *B*—Dovetail joints; *C*—Vertical joints roughened with cold chisel; *D*—Reinforced vertical joints; *E*—Scarf joints; *F*—Scarf joints scrubbed with oxalic acid; *G*—Scarf joints scrubbed with oxalic acid and treated with a paste of neat cement; *H*—Half and half, or step joints.

The reinforced vertical joints were reinforced with two ¾-in. round iron bars, 18 ins. long with nuts at either end. These bars were placed 1½ ins. from the bottom and 2 ins. from either side. The scarf joints were one-third the length of the beam and the step joints were 18 ins. long. The end of the male part of the dovetail joint was 4 ins. thick and the neck 3 ins. thick.

All beams were broken at the end of two months. The idea was not to determine the strength of these joints at the age of two months, but rather to determine their relative value when compared with each other, or to a solid beam of the same material. In the case of the gravel beams, those beams having scarf joints were found to be stronger than the solid beams. The explanation that is offered for this freak is that these beams were made in different forms than the rest of the beams. These forms were of exactly the same dimensions as the others, but of different construction, and it was found to be quite difficult to remove the beams from these forms without injury, for which reason they were not used for any other specimens. This irregularity, however, does not materially affect the final conclusions.

All these tests were made in triplicate and the average results taken except where the breaking load of one beam was so radically different from the other two that there was a doubt as to its value. In this case the average result of the two beams most closely agreeing was accepted.

The ends and sides of the forms were made of 2x10-in. rough hemlock boards. The side pieces were held in place by cleats on the end pieces and also by iron straps and bolts. The end pieces were fastened by hooks and eyes to the sides. Wooden pallets made of 1x8-in. spruce boards, cleated to raise them 1 in. above the ground, were fitted inside of the forms and served as the bottoms. The surfaces of these forms were neither shellaced or oiled and received no treatment other than that they were thoroughly wetted immediately before use.

Materials.—Crushed Rock No. 1—Dolomitic limestone passing 1¼-in. and retained on a ¾-in. screen.

Crushed Rock No. 2—Dolomitic limestone passing 1½-in. and retained on a ¼-in. screen.

Gravel—Obtained from a gravel pit along the Delaware River above Easton, Pa. All of it passed a 2¼-in. screen and was retained on 1/10-in. screen.

Sand—Bank sand, clean and sharp, grading from ¼ in. to dust.

Crushed Screenings—Obtained from crushed rock No. 2.

Cement—Alpha Portland. This cement, which successfully passed the specifications of the American Society for Testing Materials, both when manufactured and when used, had been stored in the concrete laboratory nearly four months before these tests were undertaken, which accounts for the generally low results that were obtained. Beams of the same dimensions and made with Crushed Rock No. 1, sand and the same cement when fresh, broke 30 per cent higher at half the age of similar beams in this investigation; but they were also stored in an immersion tank.

Proportioning.—All proportions of the aggregates were determined from mechanical analyses as described by Messrs. Thompson and Fuller in their report on the series of tests conducted on the materials used in the construction of the Jerome Park Reservoir. This method consists in plotting fineness curves for the materials to be used, each of whose ordinates represents the percentage of weight of the total sample which passes a sieve having holes of a diameter represented by the abscissae. These curves are then combined so that the resultant curve will approach as nearly as possible a parabola which begins at the origin of the coordinates and ends at the intersection of the ordinate of the diameter of the largest particle and the 100 per cent line.

To 5 parts of the aggregate by weight was added 1 part of cement. The finer particles of the aggregate were not replaced by the cement as is sometimes done. This of course increased the percentage of the finer particles in the final mix. All proportions were made by weight, no allowance being made for moisture, as several tests showed that the small amount present was fairly constant and in no case did it exceed 1 per cent.

All mixing was done by hand on a concrete floor. The weighed stone was spread evenly about 6 ins. deep and thoroughly moistened, the sand and cement, mixed to an even color, were spread over the stone. The materials were turned 6 times, twice dry, then with a little water added from a sprinkler, more water being used during the last three turnings to obtain the desired consistency. Care was exercised in turning, to avoid heaping the concrete, thus preventing the coarser particles from rolling to the edges. Sufficient concrete was mixed at one time to make three whole beams.

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*Condensed and rearranged from a paper before the Engineers' Society of Western Pennsylvania.

The amount of water to be used was left to the judgment of the operators. It was desired, however, to obtain a concrete of medium consistency that would quake easily like jelly, when disturbed. This was found from previous experiments to give out not only the densest, but generally the most uniform concrete. The amount of water used did not vary more than 1 per cent either way in any of the mixtures of the same materials.

The concrete was shoveled into the forms and thoroughly rammed while being placed with a ¾-in. round iron bar about 30 ins. long, having a nut on the end. At all times it was the aim to work uniformly in the preparation and testing of the specimens so that all errors or differences that might be caused by the personal equations could be elimiated or made constant.

Table I.—Showing Results of Tests of Strength of Concrete Joints.

Kind of Joints.	No. of tests arranged.	Breaking load, lbs.	Modulus of rupture, lbs.
Stone No. 1 and sand:			
Solid beams	2	3,275	345
Dovetail beams	3	1,700	178
Vertical joints, roughened	2	900	94
Scarf joints	3	2,300	242
Gravel and sand:			
*Solid beams	3	1,775	187
Dovetail joints	2	1,350	142
Scarf joints	3	1,833	193
Scarf joints with oxalic acid	2	2,200	231
Half and half joints	2	675	70
Stone No. 2 and screenings:			
Solid beams	3	3,200	337
Vertical joints reinforced	3	3,233	341
Scarf joints with oxalic acid	3	3,433	362
Scarf joints with oxalic acid and cement paste	3	3,200	337

The first half of all specimens were allowed to set 48 hours before the remainder of the beam was added. The forms were not removed until the completed beam was 48 hours old. The beams were not moved nor were they removed from their pallets until they were at least a week old. The concrete laboratory where the specimens were mixed, stored and tested, was of constant temperature, about 60° F., and somewhat damp, so it was not considered necessary to guard against the specimens drying out too rapidly.

The beams were tested under a transverse load over a 51-ft. span, the load being applied 1 ft. each way from the center of the span. A 200,000-lb. Riehle testing machine was used. Resting on the V-blocks which supported the beam was a wooden frame, which cleared the beam. This frame extended along both sides of the beam and midway between its supports were fastened two dial test gages, which read to 0.001 in. Strapped to the sides of the beam, midway between the V-blocks, were two brass rods, which supported two adjustable arms. At the ends of these arms were set screws bearing against the contact points of the dials. As the beam deflected the arms released the contact points and the deflection was thus indicated on the dial. This arrangement gave two readings, one for either side, and the average of these results gave the mean deflection of the beam at the center of the span for each reading.

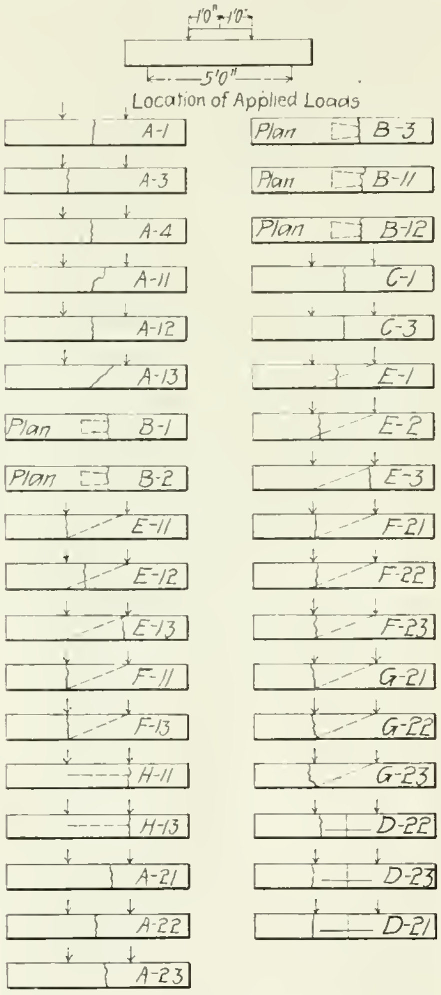

Fig. 1—Sketches Showing Joints Tested.

The load was applied in increments of 200 lbs. and the deflection noted each time. The apparatus for measuring the deflection of the beam was designed by Prof. J. M. Porter, Dean of the Civil Engineering Department at Lafayette College. Fig. 1 shows sketches of the various joints tested and the location of the fractures in the broken beams. The results of the tests are shown in Table I (compiled from the detailed data given in the paper.—Eds.)

Conclusion.—The reinforced joint proved to be the strongest joint tested, failure occurring not at the joint but beyond the reinforcement. Of the different scarf joints, which were the next strongest, those scrubbed with oxalic acid were a little stronger than those not scrubbed. The treating of the surface of the joint with a paste of neat cement from the results of these tests, proves to be of but little value. The dovetail is the next strongest joint. This type of joint, although stronger than the remaining kinds, seems to be much weaker than the scarf joints. The vertical joints roughened and the half in half, or step joints, were the weakest of all those tested. In every case they gave a low breaking strength, frequently breaking while being handled.

The thirtieth annual convention of the Ohio Engineering Society will be held in Columbus, with headquarters at the Great Southern Hotel, January 26, 27 and 28, 1909. The program of technical papers and discussions is as follows:

Road Problems in Ohio, by James C. Wonders, state highway commissioner.

An Economical Long Span Reinforced Concrete Highway Bridge, by Wilbur J. Watson, consulting engineer, Cleveland, O.

Reinforced Concrete Highway Bridges: Present Status and Possible Future Developments, by Paul R. Murray, consulting engineer, New Philadelphia, Ohio.

Table of Short Radius Curves, by W. H. W. Jenkins, surveyor and civil engineer, Portsmouth, Ohio.

Ceramic Engineering, by Prof. Edward Orton, Jr.

Coal Mining, by Prof. N. W. Lord.

Grade Crossing Elimination in Columbus, Ohio, by R. H. Simpson, assistant city engineer.

The Operation of the Columbus Sewage Purification Works, by C. B. Hoover, superintendent in charge.

Fourth Street Paving, Portsmouth, Ohio, by W. H. W. Jenkins, surveyor and civil engineer, Portsmouth, Ohio.

The State Board of Health and Engineering Problems, by Dr. C. O. Probst, executive officer of the State Board of Health.

The Improved Water Supply and Sewage System of Columbus, with Special Reference to the Developments Leading Up to These Improvements, by Julian Griggs, consulting engineer, Columbus, Ohio.

The Operation of Water Purification and Softening Plants with Special Reference to the Works at Columbus, by Wm. R. Copeland, superintendent in charge.

Over 700 miles of the Frisco system are to be equipped with block signals. The contract calls for the expenditure of $3,000,000.

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*These were the beams without joints, which showed less strength than beams having scarf joints as mentioned above.

Earth and Rock Section

Note: This Section is devoted to methods and costs of excavating earth and rock and building embankments. It will cover the grading of roads and railroads, diking and canal work, dredging, building reservoirs and earth dams, sewer and water pipe trenching, quarrying, etc.

The Methods of Constructing the Subaqueous Pipe and Electric Cableway Tunnel at Gloucester, Mass.*

BY HERMAN W. SPOONER.†

Gloucester is a city by the sea, situated, with the exception of one ward, upon an island. Naturally a water supply must be obtained for the increasing needs of the city from the mainland, and the pipes and mains must be carried under the canal that separates the island from the mainland at a sufficient depth that they will not interfere with navigation in the canal.

When the water plant was built in 1884 the single supply main was laid just below the bottom of the canal, and it served its purpose until the canal was dredged to deepen the channel. On account of this change it became necessary to lower the water and gas mains to a depth of 19 ft. below high water mark.

After due consideration it was decided to construct a tunnel beneath the channel to carry the water and gas pipes and electric cables. The tunnel was located on lands owned and controlled by the city. It was necessary to allow for an additional 10 ft. of dredging in the canal. Test wells and borings were made to determine the character of the material, with a view of locating the tunnel at the most favorable place. The work was advertised and let to Gow & Palmer of Boston, Mass.

The contract and plans required that the contractors construct two circular vertical masonry shafts, interior diameter 11 ft., one on either side of the canal, surrounded to within a few feet of the surface by steel cylinders. The methods of construction were left to the discretion of the contractor, unless objection was made thereto by the writer, and it was assumed that the constructors would place the cylinders in position in a timbered square-sheathed excavation, line them with masonry of the required thickness, and then excavate from the interior, allowing the lined cylinders to settle. A tunnel 9 ft. in interior diameter, having a brick wall 1 ft. in thickness and incased within a cylinder consisting of steel plates, was to be constructed between these vertical shafts. After the construction of the shafts and tunnel, the contractor was required to place or imbed in concrete in the bottom of the tunnel six lines of vitrified six multiple duct extending along the entire length of the bottom of the tunnel; two lines of cast iron pipe 20 ins. in interior diameter were to be placed above the concrete in which the ducts were to be imbedded, together with a 12 in. main to convey illuminating gas, all of which were to be supported upon brick piers and extended upward through the shafts to a point about $1\frac{1}{2}$ ft. below the natural surface. The vertical shafts were to be divided by brick walls 8 ins. in thickness into three compartments, the larger portion to be utilized for the water and gas mains, the other part to be subdivided into two parts or quarters to accommodate high and low tension wires or cables, both shafts were to be covered with concrete floors, entrance to be made through cast iron manholes. After considering the bid at length, it was decided to modify the plans that the cost might be reduced, and ring timber or a cylinder of pine 6 ins. in thickness to take the place of the steel plates surrounding the brick walls of the tunnel was proposed by the party presenting the bid. This alteration in the original cross section was drafted by the writer, submitted to the bidder for consideration, and in reply a bid of $26,000 was received to complete the work in accordance with the revised plans and specifications, equivalent to $200 per horizontal linear foot.

The first excavation in connection with the actual performance of the contract was made on April 1, 1905, in Marine Park, at the site of the easterly shaft. The steel cylinders, 13 ft. in diameter and more than 12 ft. high, together with a shorter section of special construction for use as a shoe or bottom piece, arrived by lighter on April 15 and were landed in the park together with a hoisting engine, derrick, pumps, and other apparatus.

A circular excavation was made for the shaft, sheathed with matched plank 2 in. in thickness, the sheathing being supported by rings of 4 in. channel iron, leaving an opening in the clear of 13 ft. 9 ins. in which to operate. At a depth of 10 ft. boulders were encountered in the coarse gravel, which were removed after blasting; water immediately began to enter the excavation in small volume and was removed by a 3 in. pulsometer pump. At a depth of 18 ft. a decided change was noted in the material, fine dead sand being found, and a decided increase in the quantity of water was evident.

On April 11, when a depth of 19 ft. had been reached, the shoepiece of the cylinder, having a special reinforced cutting edge upon which the masonry lining wall was to be constructed, was placed in position within the sheathing and a second section of the cylinder was then adjusted, the eye (or portion which was to be cut out later when the shaft was completely lowered, and through which the tunnel was to be started) centered, and preparation made to place the concrete lining. Fine screened sand was placed between the sheathing and the cylinder to fill the void and act as a guide, which later appeared to be an error, causing great loss of time and expense to the contractor.

While the sheathing was being placed for use as a form to support the concrete lining of the easterly shaft, an excavation was commenced on the westerly side of the canal at the site of the west shaft, in which many large boulders were found and removed after blasting, and from which the cables of the Postal Telegraph Company were removed. The opening was made in the same manner as the easterly excavation, the materials encountered at the several levels were almost identical with those found upon the east side of the canal.

The interior of the cylinder in the east shaft was treated with a three-ply coating of waterproofing, the steel receiving a coat of tar, and tarred paper being applied thereto, and this operation was continued until the desired amount had been placed.

Forms of dressed $1\frac{7}{8}$ in. plank were erected, supported within by rings of double angle iron, allowing for the placing of concrete 1 ft. in thickness inside the waterproofed cylinders. The following mixture of concrete was required and placed: To each 380 lbs. of dry Portland cement there was added 5 cu. ft. of fine and 11 cu. ft. of coarse crushed stone and 1 cu. ft. of clean sharp bank sand, the whole being mixed very wet.

All concrete, and all mortar used in brickwork, was mixed by hand and made with Atlas Portland cement which passed all the required tests.

The double angle iron supporting the forms were set 3 feet apart and were replaced by wooden block rings after the concrete had attained a sufficient degree of hardness. Hooked bolts were set in the concrete as the lining walls were erected, to which stagings may be attached inside the cable chambers.

When several vertical feet of the concrete lining walls had been placed, it was noted that the entire cylinder had settled about 6 in. into the gravel, the cutting edge resting upon a boulder which was found to be under the easterly edge. After this boulder had been partially removed by blasting, the structure again settled about 4 in. It was found that the boulder was of large size, and after continued small blasts, small amounts of powder being used on account of the close proximity of the cutting edge, the cylinder slipped past this obstruction reaching a depth of about 21 ft. by easy stages.

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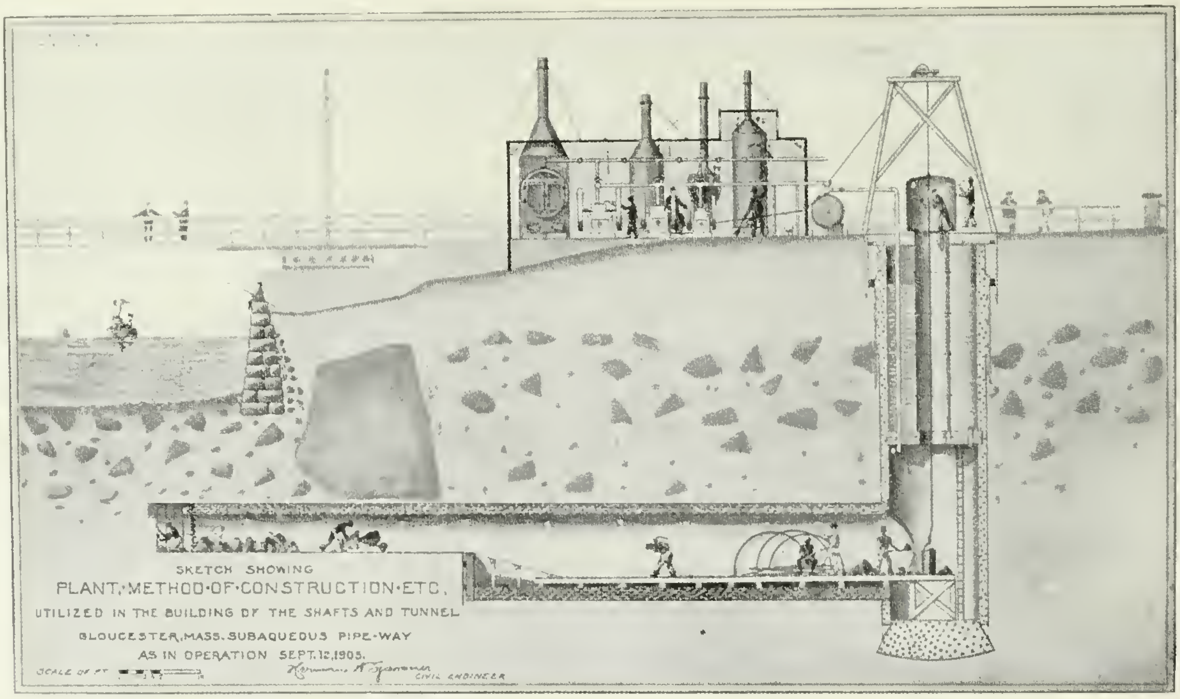
*Condensed from a paper read before the New England Water Works Association and printed in the Journal of the Association.

†Civil Engineer, Gloucester, Mass.


SKETCH SHOWING
PLANT,·METHOD·OF·CONSTRUCTION·ETC.
UTILIZED IN THE BUILDING OF THE SHAFTS AND TUNNEL
GLOUCESTER,MASS.SUBAQUEOUS PIPE-WAY
AS IN OPERATION SEPT.12,1905.
SCALE OF FT
CIVIL ENGINEER

Sketch Showing Method of Constructing Sub-Aqueous Pipeway at Gloucester, Mass.

At this time (April 24) the structure was going downward at the rate of about 20 in. in 11 hrs. and was becoming gradually out of plumb. The lowest portion of the edge was then blocked and the high side weighted with all available material, but no progress was made, the cylinder having a decided tendency to remian stationary. Another section of steel cylinder was attached to the loaded walls and lined with concrete, the structure being at this time about 6 in. out of level in the width. In this position the cylinder continued to settle slowly notwithstanding the efforts made to guide it to a level or plumb position. It was noted that the fine screened sand which had been placed between the sheathing and the cylinder shifted continually, causing the movable structure to be jammed far to one side, and on account of the shape of the excavation (round) and the impossibility of moving the sand guide at will, the space being too small, it was found to be impracticable to right the cylinder. The volume of water entering the excavation rapidly increased, and as the tide turned, the laborers were obliged to leave the bottom on account of the absence of pumps of sufficient capacity. At this time two 3-in. pulsometer pumps, assisted by a large single-cylinder Emerson pump, were in continuous operation, the depth of the excavation being about 25 ft. below the surface of the park and about 5 ft. below the low-water mark in Gloucester harbor. It was the intention of the contractor to complete the work without the use of compressed air, treating the ground through which the work was to be built with cement grout, this method being less expensive and having been used to advantage in other and similar work. Here, however, it was found that the nature of the gravel was such that the ground waters at all times moved freely through the ground, so that there was no opportunity at any time to leave grout in place for a sufficient period to allow of its attaining the initial set. Therefore, on May 2, the contractor decided to resort to the use of the pneumatic method of construction. At this time the bottom or cutting edge of the cylinder was about 7 ft. below low-water mark, it being necessary to lower the structure about 20 ft. further before the required depth was reached. During the next two days the cylinder was worried down to a bed consisting of very coarse, hard gravel and isolated to a depth of 28 ft. below the surface of the park.

A recess was cut in the concrete lining to receive the wooden deck which was to support the compressed air tube and lock, and work in the east shaft was abandoned until the apparatus, air compressor, additional boilers, etc., could be assembled.

The cylinders to be placed within the excavation on the west side of the canal were rolled across the drawbridge and placed in correct order inside the sheathing with the aid of shears, power being furnished from the plant on the east side of the canal. Before being placed in position, six skids or guides consisting of timber 4x6 in. in size were affixed by lag screws to the sheathing, being notched at each ring of channel-iron, this pattern of a guide being used in place of the screened sand used in the east shaft. The inside of this cylinder was treated in the same manner as was the one in the opposite shaft and the walls constructed of concrete, an air deck, 18 in. in thickness, being built into the walls as the work progressed. The materials encountered in excavating were nearly identical with those found in the east side except that strata of gravel mixed with iron through which the water entered freely were passed through.

The pumping apparatus was moved to the west shaft and an attempt made to work this cylinder to a greater depth than was reached in the east shaft, but when a level had been reached which was within a fraction of an inch of the level of the bottom of the first shaft, the contractor was forced to abandon operations and wait for the application of compressed air.

While work was being carried forward on the westerly side of the canal, a small compressor with a receiver had been installed near the derrick on the east side of the canal, and on May 27 the air-lock and tubing especially designed and built for this work arrived and were ready, together with the head-house, and in operation, four days thereafter. Previous to this time there had been very little continuous work, and as when using the pneumatic method there is a continuous expense to maintain a dry excavation, two shifts were organized. Each shift worked eleven hours and consisted of foreman, stationary engineer, fireman, locktenders, miners, tenders, and muckers, generally eleven men being emmployed during each shift. The men employed upon this work were of the first rank in their several vocations, exercising great care in the performance of the duties assigned to them, and on this account, if for no other reason, the writer is pleased to be able to state that there were no men injured during the execution of this contract, and the final result is entirely satisfactory.

The air compressor was in operation thereafter continually until the work was nearly completed. All materials were removed, and all materials required in construction were transferred, through the air lock, thus increasing the cost of construction nearly four fold.

The cylinder was bound in such a manner that although the gravel was excavated from beneath the cylinder to a depth of 3 ft. and additional weight was added in the form of water on the deck and piles of brick upon the rim, it did not drop until all the air-pressure had been removed and the earth at the sides of the cylinder commenced to heave inward. This passage of gravel or "heave" from around the cylinder and about the sheathing down and into the void excavated and into which it was desired to drop the structure caused trouble throughout the entire lowering of this shaft, also until the tunnel was completed about 10 ft. from the side or eye. Often after working for an entire shift, when air pressure was removed, a net gain in depth of only 1 ft. was made, while at other times only 3 ins. were gained.

Poling boards were used beneath and in the rear of the cutting edge to hold back the material which had a decided tendency to heave, but with little effect. In some instances over 4 ft. of sand and gravel rushed in when the pressure was removed, requiring nearly an entire shift of work to remove it.

In order to increase the weight of the cylinder, hundreds of tons of pig-iron were placed upon the deck and walls in the endeavor to drive the cylinder down, but even under this added weight it still remained firm.

The sand used as a guide had shifted and the surrounding ground settled or slumped, carrying sheathing and channel-iron rings with it to such an extent that the head-house was unstable, a cavity extending nearly 10 ft. from the cylinder in all directions being open. Heavy timbers were placed to span the hole and support the superstructure, being held together with heavy chains.

It was decided at this time to drive a square set of sheathing outside the circular set originally placed, in an attempt to reach the channel-iron rings which were evidently jammed between the steel cylinder and the original sheathing; also to support the earth and prevent further caving. This was accomplished with considerable difficulty, it being found that the rings were in close contact with the cylinder, being much lower on one side of the cylinder than on the other, also that the heads of a few of the rivets used in making the joints of the cylinder had been entirely cut or scraped off as it had slid through the ring. Two rings were cut and the accessible portions removed, after which a boulder that had slid in and bound against the cylinder was broken and removed.

The work of excavating was recommenced beneath the cylinder after sections of the tube leading from the air lock to the deck had been placed in position, and the cylinder was lowered after continued and discouraging efforts, as at no one time did it go down more than 20 ins.

Grade lines were drawn across the cylinder on June 23 and preparations made for a final drop to the required grade. After the air pressure was removed the structure settled gradually, and when the desired point was reached, the air pressure was applied, but before there was sufficient pressure to counteract the weight, it had settled nearly 1 ft. below the line.

A space was immediately excavated below the cutting edge and poling boards placed in such a position as to allow for the placing of a concrete foundation of much larger diameter than the cylinder. The center of the excavation was dished to a depth of 8 ins. below the sides or ends of the poling boards, the material at the bottom and upon which the foundation was placed consisting of a mixture of coarse and fine hardpan gravel, in which, on account of its firmness, it was difficult to make an impression with a pick.

A pressure of 17 lbs. per sq. in. was maintained while depositing the concrete for the foundation, placing the waterproofing, and until the whole mass had firmly set; the cavity around the shaft was filled and preparations made to extend the walls of the shaft upward.

The power plant upon this work July 1 consisted of three boilers, including the one used in connection with the hoisting engine, all being piped together and making a total of 50 h. p. to operate the hoisting engine and compressor. At this time it was decided to make a trial of the use of cement grout to harden the ground through which the tunnel was to be driven. A small 2-in. opening was made in the steel cylinder in the upper part of the eye 12 ft. in diameter, which had been left free from concrete when the walls were formed, a thin mixture of grout was prepared and an attempt made to force it into the sand and gravel surrounding the steel casing, but after several attempts the idea was abandoned, as it seemed, under existing conditions, impracticable, it being only possible to solidify a very small section of the material directly surrounding the delivery point of the grout.

As the excavation was progressing at the different levels, corresponding to those through which the tunnel was to be driven, careful examination was made with the result that when it was found that the solidification method was impracticable, recourse was had to the original method of using steel plates to support the earth above and upon the sides of the tunnel, while the masonry walls were placed with the aid of compressed air. A supplementary agreement was drawn and the contractor granted permission therein to use steel plates in place of ring timber provided that the masonry walls, inclusive the waterproofing and plaster, were constructed to a minimum thickness of 18 ins., a thickness equal to the proposed ring timber and brick wall. This agreement was signed, plates ordered, and preparations made to cut out the eye. On July 3 a 50 h. p. upright boiler was added to the existing plant. The work of cutting the steel cylinder progressed very slowly on account of the disadvantages under which the men labored, the positions necessarily occupied in holding and striking the points being decidedly awkward. After about 170 hours of continuous work by entire shifts with diamond points, a part of the upper portion of the eye was removed and it became evident that the channel-iron rings which were mentioned as having been used as a support for the original sheathing were to continue to disturb operations. Directly across the opening made in the side of the cylinder two of the rings were found twisted completely around each other, having been carried down at least 18 ft. while in close contact with the cylinder, thus causing friction which retarded the settling of the cylinder. The sections of rings spanning the eye were cut out and the excavation continued.

As there was no clay encountered in this work, the necessary amount of clay was hauled from the location of an old clay pit, a distance of about 800 yds. This clay was not of the best quality for this work but was as good as could be readily procured, the disadvantage in its use being that upon application to the gravel breast and plate joints it dried, causing crevices to immediately appear through which the air freely issued; consequently, it was necessary to keep men continually employed dampening and renewing the clayed surface.

On July 12 the need of an addition to the air compressor plant was noted, as the small high-pressure engine delivering about 300 cu. ft. of air per minute seemed to be inadequate, the temperature in the heading rising to such a degree that an effort was made to cool the air with water and ice previous to sending it into the work and thus enable the men to work freely. The opening in the top of the eye was only 18 ins. in depth at this time, and on account of the loose nature of the ground, the single compressor was working to its full capacity in order to maintain sufficient pressure to keep the water away from the breast.

A few small boulders were encountered in this first opening which were removed without difficulty. For four full days or eight shifts the men labored in excessive heat depending upon the one compressor and succeeded in driving the arch of the tunnel a distance of four plates, or 4 ft. from the side of the vertical shaft. After two more rings were added it was decided to suspend operations and seal the heading with clay until another compressor could be installed, as it was decidedly dangerous to excavate further and depend on the one compressor then operating at its full capacity to maintain the required pressure.

On July 22 another high-pressure capable of delivering about 800 cu. ft. of air per minute was installed and in operation, working in conjunction with the other, and the work was again rushed forward.

The contractors at this time realized the necessity of still further increasing the plant by the addition of another boiler, as the three small boilers on the work were taxed nearly to their entire capacity. When the arch had been driven a distance of 8 ft. the needle-beam, consisting of a timber 10 ft. in length, 12 ins. square, was placed in position, and the work of removing the lower half of the eye of the cylinder was commenced. The plate-joints and breast were completely covered with successive coatings of clay to hold the air, and even then it required the operations of both compressors at a high speed to maintain sufficient pressure, the thermometer registering 100 degrees in the heading and 90 degrees in the lock. The continuous labor (eleven hours) in humid compressed air at such high temperature began to affect the laborers and they were obliged to come out through the lock at intervals for change of air. On July 27 the brick masons laid the first section of invert and completed the arch and work around the eye on July 29, laboring in the intense heat nearly 45 hours to complete the section 6 ft. in length.

A temporary bulkhead of plank and bags of clay was placed in the invert at the end of the completed section, and the heading again opened. While this work had been progressing, another boiler (capacity 150 h. p.) had arrived, the entire plant being connected and in working order on August 3; the heading had now been extended a distance of 12 ft. through coarse gravel and boulders. At this time the larger of the two compressors became jammed and was out of commission for a few minutes, the whole load resting on the small compressor. During the strain this compressor turned 140 revolutions per minute, and although the pressure gradually dropped, the single engine held sufficient pressure until the defect was repaired and both were running.

It was evident to the writer that there was not sufficient duplication of plant upon the work, and in consequence he requested the contractors to still further add to the existing plant a compressor delivering at least 1,100 cu. ft. of air per minute. Under the conditions, it was unsafe to carry on operations in the heading, not only on account of the danger to the laborers, but also on account of the danger of loosening or the caving in of the breast and the loss of time in again recommencing operations.

On Aug. 16, 26 ft. of the walls of the tunnel had been completed, and the contractors had decided to send a third compressing engine to the works, had procured a large low-pressure machine, capacity 1,100 cu. ft. per minute, and assured the writer that it would be in operation within a few days.

The contractors kept in touch with the work, and knowing well the delicacy of the operation of driving the tunnel through the coarse gravel and stray boulders that might be encountered, suggested a decided change in the method of construction. Under the bed of the canal the roof of the tunnel was to be constructed within 11 ft. of low-water mark, the bed of the canal being practically dry at low tide. The amount of material above the work was deemed insufficient to hold sufficient pressure to allow for the construction of a full section of the tunnel wall; therefore it was decided that when the completed walls had been erected to within a safe distance of the canal, the upper half or arch should be driven and the arch wall completed under and as far as the westerly side of the canal to a point beneath the retaining wall.

The last addition to the plant consisted of a large low-pressure compressed air engine, having a capacity of 1,100 cu. ft. per minute, and was installed and in operation on Aug. 23. It was found that the difference in the temperature in the tunnel was about 20 degrees, being much lower than when the air was supplied by the small compressors; it was also noted that sufficient air could be supplied by the new engine and half speed on the second machine, allowing for repairs on the third or smallest engine.

The work hereafter progressed more rapidly, and on August 28 46 ft. of the tunnel wall was completed, and on September 1 a gain of 10 ft. additional had been made.

At a point about 56 ft. from the easterly shaft a temporary bulkhead was erected, filling the bottom of the tunnel or invert to within a few inches of the spring line, composed of a brick wall 12 ins. in thickness and backed by clay puddle. This dam or bulkhead remained in place until the arch walls were completed under and beneath the western walls of the canal. During the construction of this arch about 9½ pounds of pressure was sufficient to carry on the work. When the tunnel had been driven to a point within 20 ft. of the easterly canal wall a slight leakage of air was noted in the waters passing through the canal. This disturbance continued to increase as the work was extended, and when it had progressed to a point directly beneath the canal, the air rushed up through the waters in such volume from the heading that the canal for its entire width and a distance of 50 ft. up and down stream resembled a boiling caldron, which was watched with much interest and speculation by large numbers of people from the bridge.

This work of driving the arch had progressed only a few feet when a boulder was uncovered in the roof extending across the heading for a distance of 5 ft. and hanging into the opening about 2 ft. A few light charges were fired in small hand-holes made on the under side of the boulder, but no marked effect was made. Drilling and splitting was then commenced, and after nearly a week of continuous work the roof-plates were made secure beneath the stone, a sufficient amount of the boulder having been removed. Several small boulders were found, split, and removed from the heading, remaining in the completed tunnel until the air deck was removed, as they were too large to move through the lock.

During the progress of this part of the work the ground occupying the position of the invert remained undisturbed, the bench or ground below the spring line being covered with a layer of clay 6 ins. in thickness, having an overlayer of boards. It was quite a difficult task and required continuous watching to keep the pressure at an amount sufficient to keep the water from entering under and through the clay floor, and again not enough to lift the canal bottom and cause a blowout, it being necessary to watch the rise and fall of the tide and regulate the pressure according to its different levels.

During this part of the work the smallest error in air pressure could but result in severe monetary loss to the contractors and possibly the loss of the lives of the men employed in excavating the heading. The materials excavated were coarse sand and gravel, through which the air rushed freely when not retarded by the coating of clay applied from within, and was removed from its original position by small trowels. This gravel, after being dug out with the trowels and dropped on the bench, was shoveled into a single wheelbarrow and transferred to the shaft. Here it was again shoveled into a bucket to be lifted into the air lock. From the lock it was dumped into carts and hauled to the dump. Thus it will be understood that the gravel excavated was handled five different times before being finally dumped, making the expense heavy.

Several times during the perilous part of the work on the arch, the earth was driven upward by the air pressure or fell away, leaving a large aperture through which the air roared to the surface. During these periods the whole compressor plant was operated to its entire capacity; these voids were immediately filled with clay, bags, or any cloth or material which would stop the outrush of air, the miners knowing that were these voids not filled at once the pressure would relax and the waters from the canal and the harbor rush in. On September 21 the arch was completed to a point about 14 ft. from the western shaft and beneath the westerly side wall of the canal, and a solid brick bulkhead erected. This bulkhead was built within the completed arch and about 1 ft. back from the toothing, thus leaving sufficient brickwork for connection with that part of the tunnel which was to be built from the westerly shaft.

The first temporary brick bulkhead was now removed and the invert constructed, the connection between the arch and invert being made tight by splitting brick in form of a wedge and driving tight. This being neatly executed, the circular section was made complete to the terminus of the work to be accomplished from the east side. The bulkhead having been completed and braced by heavy raker timbers stepped into the brick invert, the air pressure was removed and the air tube and lock transferred and fastened in position in the west cylinder, the air and water supply pipes were suspended over the canal, the head house placed in position, and the work of settling the western shaft commenced on October 6.

The west cylinder, having timber guides, settled rapidly, the cutting edge being kept in contact with the bottom, slipping down when the air pressure was slightly reduced; thus the trouble of the heaving of gravel, as was experienced in sinking the east shaft, was avoided, and on October 9, 12 ft. of progress downward had been accomplished. On October 13 the cylinder reached the required level and the concrete walls were extended upward toward the surface. The excavation was made and foundation placed similar to that in the east shaft, and the work of cutting out the eye of the tunnel in the steel cylinder commenced. The levels and lines were transferred through the deck and preparations made to excavate for the arch. This work was commenced on October 19 and six days thereafter the toothing of the completed section and bulkhead was met, and on October 30 the continuous walls of the tunnel were complete from the east to the west shaft. The work of calking, cement washing, and finishing was begun immediately after the bulkhead was removed the fires were drawn in the larger boiler and it was removed. On November 1 the night shift was discharged, the work thereafter being carried on by one gang during the day. Three days thereafter the air pressure was withdrawn, and the writer was gratified to note that there were very few damp spots throughout the entire length of the tunnel.

The drains from the west shaft to the east shaft were laid, above which the ducts (six lines of six multiple vitrified duct) were laid in the invert or bottom of the tunnel, air pressure of 15 to 20 pounds per square inch being maintained until all were in place and covered with concrete. These six lines of duct were divided into two sections, being imbedded in the concrete, the joints waterproofed, and separated by a wall of concrete 1 ft. in thickness, one side to be ocupied by high tension, the other by low tension cables; the concrete covering was overlaid with fine plaster, which serves as a floor.

The water mains, two lines of 20 in. cast iron pipe, were next placed above the floor, supported upon brick piers on either side of the tunnel, the 12 in. gas main being supported in like manner in the center. These lines of pipe were extended up through that portion of the shafts designed for their occupancy, and the partition walls erected.

The ducts were wired, a line of wire extending from one shaft to the other through each duct to serve as a lead wire when placing the cables later.

The reinforced concrete roofs or covers were laid and the manhole caps and covers placed in position, the grounds around the shafts were graded, and the tools and machinery removed. The Board visited the tunnel on December 22, together with the writer, and after a thorough inspection, decided that the difficult task of building a practically waterproof tunnel and appurtenances under numerous disadvantages had been acceptably completed, and upon the following day the contractor was notified of the acceptance of the work.

The leakage of the tunnel and shafts is at this time much less than in any tunnel now completed in this country of which the writer has knowledge, being less than one-half gallon per minute, with evidence that this will be reduced in the future. When the material through which this work was built is considered, together with the several obstacles encountered, the contractor is to be congratulated upon the success of the undertaking and the fact that no person was injured during the work.

(We give space to this article as the author has described every step taken and all the methods used in carrying out a difficult piece of construction. The work is not unusual, as subaqueous tunnels are being built in many sections of the country, but the descriptions published have been, as a rule, general rather than specific. In this instance the work seems to have been well done and without an accident to those engaged in the work. However, one comment can be made upon the job. It was evidently a mistake for the contractor not to have supplied the proper plant from the outset. If the outfit that was on the job when it was completed had been installed at the start, the work would have been done quicker and cheaper.—Ed.)

Cost of Canal Excavation, Huntley Irrigation Project.*

Division 1 of the Main Canal of the Huntley Project contains a section of about 800 ft. in length, having a depth of 17 ft., a base of 14.5 ft. and side slopes of ½ on 1. In addition to the material covered in this prism, there were about 2,000 cu. yds. of material excavated above the general level on one side of the canal extending to the top of a cliff along the base of which the canal takes its course. The work of excavation of this section of the canal was done by contract, and below is given a summary of the cost of the work to the contractor. The excavation was divided into the three following classes: Class 1, earth or material that could be plowed and handled with scrapers; Class 2, loose rock varying in volume from 2 to 20 cu. ft.; Class 3, solid rock or material not included in either of the foregoing classes. Most of the material consisted of a bluish gray sandstone of medium hardness and was paid for under Class 3.

	Class 1. 391 cu. yds.		Class 2. 1,507 cu. yds.		Class 3. 6,427 cu. yds.	
Distribution of cost.	Total.	Unit.	Total.	Unit.	Total.	Unit.
Executive	$ 3.33	$0.009	$209.09	$0.139	$817.17	$0.127
Labor	36.75	0.094	972.80	0.646	5,818.05	0.905
Supplies	.....	.....	.....	.....	664.24	0.103
Total	$40.08	$0.103	$1,181.89	$0.785	$7,299.46	$1.135

The material excavated from the main prism of the canal was loosened by blasting with 40 per cent gelatine dynamite. All drilling for blasting was done by hand and the drill holes were extended to subgrade and filled with sufficient explosive to loosen all rock within the line of excavation transversely. About two-thirds of the material was removed in small cars of ½ cu. yd. capacity. The finer portions of the remainder were loaded by hand into one-horse dump carts and hauled a distance of about 200 ft., and the larger pieces were rolled onto sheet steel sleds, which were unloaded by driving the sleds over the side of a near by dump, causing the rock to roll off from the sled. The material taken from the cliff above the canal prism was handled in the same manner as the coarser portions from the canal prism.

The principal superintendent was paid at the rate of $6.67 per 8-hour day, the assistant superintendent, $5.75; the foreman, $3.25; laborers, from $2 to $2.40; single horse and cart, $1; team and car, $2; team and driver, $4; blacksmith, $2.80.

In the accompanying table the cost of the principal and assistant superintendent and the foreman has been charged under Executive, the cost of all other work under Labor, and the cost of coal, oil and blasting material under Supplies.

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*Reclamation Record, January, 1909.

Roads and Streets Section

Note: This Section is devoted to methods and costs of road and street construction. It will cover road building in all its details, the construction of pavements, sidewalks and gutters, the testing and use of paving materials and the machinery and tools used in road building and paving.

Standard Specifications for Portland Cement Roads and Portland Cement Sidewalks.

Separate specifications for cement roads and cement walks were presented to the National Association of Cement Users at its annual convention held Jan. 13 to 16, by a committee composed of W. W. Schouler, President Standard Paving Co., Newark, N. J.; C. W. Boynton, Inspecting Engineer, Universal Portland Cement Co., Chicago; G. F. Lillie, Concrete Contractor, Lincoln, Neb.; George L. Stanley, Concrete Contractor, Ashtabula, O., and N. P. Winchell. The two specifications are in large part identical and we therefore combine them here, with such notations as will enable the reader to separate the parts making up either the walk or the road specifications.

MATERIALS.

The cement shall meet the requirements of the specifications for Portland cement of the American Society for Testing Materials, and adopted by this Association (Specification No. 1), January, 1906.

AGGREGATES.

Fine Aggregate shall consist of sand, crushed stone, or gravel, screenings, graded from fine to coarse, passing when dry a screen having ¼-in. diameter holes, shall be silicious materials, clean, coarse, free from vegetable loam or other deleterious matter, and not more than 6 per cent shall pass a sieve having 100 meshes per linear inch.

Mortars composed of 1 part Portland cement and 3 parts fine aggregate by weight when made into briquets shall show a tensile strength of at least 70 per cent of the strength of 1-3 mortar of the same consistency made with the same cement and standard Ottawa sand.

Coarse Aggregate shall consist of inert material, graded in size such as crushed stone, or gravel, which is retained on a screen having ¼-in. diameter holes, shall be clean, hard, durable, and free from all deleterious materials. Aggregates containing soft, flat or elongated particles shall be excluded.

The maximum size of the coarse aggregate shall be such that it will not separate from the mortar in laying and will not prevent the concrete fully filling all parts of the forms. The size of the coarse aggregate shall be such as to pass a ¾-in. ring.

Where cinder concrete is permissible the cinders used as the coarse aggregate should be composed of hard, clean, vitreous clinker, free from sulphides, unburned coal or ashes.

Water shall be clean, free from oil, acid, strong alkalies, or vegetable matter.

FORMS (1).

Forms shall be of lumber, free from warp, and not less than 1¾ ins. thick. All mortar and dirt shall be removed from forms that have been previously used.

The forms shall be well staked to the established lines and grades, and their upper edges shall conform with finished grade of the road, which shall have sufficient rise from the curb to provide proper drainage; but this rise shall not exceed one-quarter (¼) of an inch per foot, except where such rise shall parallel the length of the walk.

At each division cross forms shall be put in the full width of the roadway and at right angles to the side forms.

All forms shall be thoroughly wetted before any material is deposited against them.

SUB-BASE.

The sub-base shall be thoroughly rolled (with a 5-ton roller) to the proper slope—10 ins. below the finished grade, and all soft spots removed and replaced by some suitable hard material (2).

The top of all fills shall extend at least 24 ins. (3) beyond the roadway.

While compacting, the sub-base shall be thoroughly wetted and shall be maintained in that condition until the concrete is deposited.

BASE.

The concrete for the base shall be not less than 6 ins. thick and (4) so proportioned that the cement shall overfill the voids* in the fine aggregate by at least 5 per cent, and the mortar shall overfill the voids in the coarse aggregate by at least 10 per cent. The proportion shall not exceed 1 part of cement to 8 parts of the fine and coarse aggregates.

When the voids are not determined, the concrete shall have the proportions of 1 part cement, 3 parts fine aggregates and 5 parts coarse aggregates. A sack of cement (94 lbs.) shall be considered to have a volume of 1 cu. ft.

MIXING.

The ingredients of concrete shall be thoroughly mixed to the desired consistency, and the mixing should continue until the cement is uniformly distributed and

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*To determine voids, fill a vessel with sand and let net weight of sand equal B. Fill same vessel with water and let net weight of water equal A.

$$\text{Per cent voids} = \frac{A \times 2.65 - B}{A \times 2.65} \times 100.$$

This formula may also be used in determining voids in crushed stone and screenings by substituting for 2.65 the specific gravity of the stone.

The following is a more simple method for determining voids in coarse aggregate: Fill a vessel with the aggregate and let net weight aqual B. Add water slowly until it just appears on the surface and weigh. Let net weight equal A. Fill same vessel with water and let net weight equal C.

$$\text{Per cent voids} = \frac{A - B}{C} \times 100.$$

Use a vessel of not less than ½ cu. ft. capacity. The larger the vessel, the more accurate the results.

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(1) In walk specifications add following paragraph: A metal parting-strip ½ in. thick shall take the place of the cross-forms at least once in every fifty (50) linear feet of walk. When the walk has become sufficiently hard, this parting-strip shall be removed and the joint filled with suitable material prior to opening the walk to traffic. Similar joints shall be provided where new walks abut curbing or other cement or stone walk.

(2) Substitute in walk specifications for this paragraph the following:

When a fill exceeding 1 ft. in thickness is required, it shall be thoroughly compacted by flooding and tamping in layers of not exceeding 6 ins. in thickness, and shall have a slope of not less than 1 to 1½.

(3) Substitute in walk specifications, 12 ins.

(4) Omit in walk specifications.

(5) For walk specifications add to this section the following: (c) Hand Mixing.—The sand shall be evenly spread on a level water-tight platform, and the cement spread upon the sand. After thoroughly mixing, dry, to a uniform color, water shall be added in a spray, and the mass turned until homogeneous mortar of even consistency is obtained. To this mortar shall be added the required amount of stone or gravel previously drenched, and the whole shall then be mixed until all the aggregate is thoroughly coated with mortar.

Where unscreened gravel is used, the cement and gravel shall be thoroughly mixed, dry, until no streaks of cement are visible. Water shall be added with a spray in sufficient quantity to render, when thoroughly mixed, a concrete equivalent to that specified above.

Water may be added during the process of mixing, but the concrete shall be turned at least once immediately after its addition.

Separation of the blocks should be done with a tool not over six (6) inches wide and ¼ in. thick, and to insure complete separation the groove should be cut through into the sub-base. Fill the groove with dry sand before the top coat is spread, and the top coat should be cut through to the sand after floating and troweling and a jointer run in the groove; then again draw a trowel through the groove, so as to insure a complete separation of the block.

(6) For walk specifications substitute following: The wearing course shall have a thickness of at least three-quarters (¾) of an inch.

The mortar shall be mixed in the same manner as the mortar for the base, but the proportion of 1 cement to 2 of fine aggregate, and it shall be of such consistency as will not require tamping, but will be readily floated with a straight-edge.

The mortar shall be spread on the base immediately after mixing, and in no case shall more than 50 minutes elapse between the time that the concrete for the base is mixed and the time that the wearing course is floated.

After being worked to an approximately true surface, the slab markings shall be made directly over the joints in the base with a tool which shall cut clear through to the base and completely separate the wearing courses of adjacent slabs.

The blocks shall be rounded on all surface edges to a radius of not less than ¼ in.

When partially set, the surface shall be troweled smooth.

On grades exceeding 5 per cent, the surface shall be roughened. This may be done by the use of a grooving tool, toothed roller, brush, wooden float or other suitable tool; or by working coarse sand or screenings into the surface.

If color is desired, only mineral colors shall be used, which shall be incorporated with the entire wearing surface.

(7) In walk specifications substitute "three days."

(8) Omit from walk specifications.

the mass is uniform in color and homogeneous, since maximum density and therefore greatest strength of a given mixture depends largely on thorough and complete mixing.

a. Measuring Proportions. Methods of measurement of the proportions of the various ingredients, including the water, shall be used, which will secure separate uniform measurements at all times.

b. Machine Mixing. When the conditions will permit, a machine mixed of a type which insures the proper proportioning of the materials throughout the mass should be used, since a more thorough and uniform consistency can be thus obtained.

c. Hand Mixing. When it is necessary to mix by hand, the mixing should be on a water-tight platform and especial precautions should be taken to turn the materials until they are homogeneous in appearance and color.

d. Consistency. The materials shall be mixed wet enough to produce a concrete of such a consistency as will flow into the forms and about the metal reinforcement, and which, on the other hand, can be conveyed from the mixer to the forms without separation of the coarse aggregate from the mortar.

e. Retempering. Retempering mortar or concrete, *i. e.*, remixing with water after it has partially set, shall not be permitted.

PLACING OF CONCRETE (5).

a. Methods. Concrete after the addition of water to the mix shall be handled rapidly, and in as small masses as is practicable from the place of mixing to the place of final deposit, and under no circumstances should concrete be used that has partially set before final placing. A slow setting cement should be used when a long time is liable to occur between mixing and final placing.

When work is resumed, concrete previously placed shall be roughened, thoroughly cleansed for foreign material and laitance, drenched and slushed with a mortar consisting of 1 part Portland cement and not more than 2 parts fine aggregate.

The faces of concrete exposed to premature drying should be kept wet for a period of at least seven days.

b. Freezing Weather. The concrete for reinforced structures shall not be mixed or deposited at a freezing temperature unless special precautions are taken to avoid the use of materials containing frost or covered with ice crystals, and in providing means to prevent the concrete from freezing after being placed in position and until it has thoroughly hardened.

Workmen shall not be permitted to walk on freshly laid concrete, and where sand or dust collects on the base it shall be carefully removed before the wearing surface is applied.

WEARING SURFACE (6).

The wearing course shall have a thickness of at least four (4) inches.

The concrete shall be mixed in the same manner as the mortar for the base, but the proportion of 1 cement to 3 of fine aggregate, 6 parts coarse aggregate, and it shall be of such consistency as will not require tamping, but will be readily floated with a straight edge.

The concrete shall be spread on the base immediately after mixing, and in no case shall more than 50 minutes elapse between the time that the concrete for the base is mixed and the time that the wearing course is floated.

All surface edges shall be rounded to a radius of not less than ¼ in.

SINGLE COAT WORK.

Single coat work shall be composed of 1 part of cement, 2 parts of fine aggregate and 3 parts of coarse aggregate.

The concrete shall be firmly compacted by tamping and evenly struck off and smoothed to the top of the form. Then, with a suitable tool the coarser particles of the concrete shall be tamped to a depth which will permit a mortar finish.

PROTECTION AND GRADING.

When completed, the road shall be kept moist and protected from traffic and the elements for at least three weeks (7).

(8) Grading after the roadways are ready for use should be on the curb side of the roadway, one and one-half (1½) inches lower than the roadway, and not less than one-quarter (¼) inch to the foot fall towards the curb or gutter. On the property side of the road the ground should be graded back at least two (2) feet and not lower than the road; this will insure the frost throwing the road alike on both sides.

The first definite plan for the proposed $50,000,000 downtown system of subways for Chicago, Ill., was presented to the Council Local Transportation Committee on Jan. 6, in a report from John Ericson, City Engineer, and T. T. Johnston, Assistant Chief Engineer. The report, which was preliminary in form, suggested that the first work should be the construction of a 4 track subway north and south through Wabash Ave. from the vicinity of Chicago Ave. and Orleans St. to State and 22nd Sts. Accompanying the report was a trial design for a subway constructed of reinforced concrete.

Tarviated Motor-Testing Track

The accompanying halftone shows the half mile testing track at the Kenosha, Wis., automobile factory of the Thomas B. Jeffery Co. It is the custom at this factory to give all the Rambler cars a test of 200 miles driving on the testing track. The output of the factory is very large, so that 15 or 20 cars are running at high speed over the track every hour of the day.

Ordinary macadam would of course have suffered under such a test, and the dust would be unbearable, especially at the turns. Various oil treatments and compounds were experimented with, and the Tarvia treatment was finally adopted. It has been found entirely satisfactory. The surface is stated to be entirely without dust, to be impervious to water and so elastic that wear on the tires has been greatly reduced. The success of Tarvia on the Rambler track has been so marked that it has led to the use of this material on all the roads surrounding the factory.

Automobile Testing Track at Kenosha, Wis.

A project is under consideration by Sir Arthur Lawley, Governor of Madras, according to press dispatches, for connecting the Island of Ceylon with the mainland of India by means of bridges and a causeway. As proposed, a bridge would be built over the Paumben Channel from the mainland of India to the Island of Rameswaram and from the Island of Ceylon a bridge would be built to the Island of Mannar. Between the southern end of the Island of Rameswaram and the northern end of the Island of Mannar, a distance of 38 miles, there is an almost continuous coral reef, either covered with shallow water or rising above the level of the sea in numerous coral islets. It is thought that it would be an easy matter to construct a causeway along the line of the coral reef, and in fact it has been estimated that this could be done for about $8,000,000.

A cement users and contractors' convention and manufacturers' exhibition is to be held at Oklahoma City, Okla., on Feb. 9, 10 and 11. D. C. Patterson, 336 Bassett Bldg., Oklahoma City, Okla., is in charge of arrangements.

Unclassified and General Articles

Note: This section is devoted to methods and cost articles on construction work not properly coming under any of the preceding classifications.

Comments on the Manufacture and Use of Steel Rails.

BY FRANKLIN E. ABBOTT.

(Concluded from p. 22, Jan. 6 issue.)

Another difficult part in the making of steel rails is in the section. In the first place, it has to be very close to mathematically correct. A finished rail is a simple looking thing when it is made, but there are a good many dimensions besides the length to take into account in getting it through the mill in proper shape.

The ordinary rail section is made up of seventeen separate and distinct dimensions, nine of which are duplicated, making a total of twenty-six to be kept in order and held in their respective places when the rolling is under way.

The section is continually checked during the process of rolling. This is done by a steel template made to exact dimensions of one-half the rail divided by its vertical axes.

The rail section is tested on both sides by the same template, and therefore each half is as nearly like the other as possible to make it. In checking rail sections, the inspector has to guard against either over or under size and always strives to maintain perfect symmetry. In this detail, difference of 1-64-in. cannot be ignored and the wonder is how such ponderous and coarse machinery as constitutes a rolling mill can be so nicely adjusted as to accomplish such fine results. It is not easily done, and it should be remembered that the turning or shaping of rolls and the manipulation of steel through them when rolling is under way, is the most intricate part of the rail-making process.

The history of the "Tee" rail section from its origin to the present time, as we now have it, makes a very interesting story, but rather too long to include in this paper.

It is of interset, however, to note how closely in shape the Tee rails, at the present time, are to those first made for use in this country.

In the year 1830, Robert L. Stevens, President and Chief Engineer of the Camden & Amboy Railroad, received orders to visit England to inspect and report upon railroad matters there; he was directed to purchase all iron rails. It should be noted that previous to this time rails had been made largely of a combination of wood and iron, and the inference is that instructions to purchase *all iron* meant that the rails should be made of one piece and one material, and that should be iron.

It was during this voyage that Mr. Stevens designed the first rail ever rolled with a base. He whittled several model sections out of wood, which he obtained from the ship's carpenter. The shape finally taken was in general outline similar to the present rail, having a head about two inches wide, a base three inches wide, and height three and one-half inches. Rails of this general type of various weights were made for the next thirty years or more. After the Civil War, when practically all the railroads then in existence had to be rebuilt and new ones became necessary, the tee rail section was improved in detail, and in 1874 sections were brought out almost identical with many still in use. During the next fifteen years rail sections in great varieties of dimensions were produced. Nearly every railroad had its own design, and it is stated that one rolling mill, at a certain time, during this period, in undertaking to supply its customers with such as were called for, had to provide rolls for 119 different patterns.

The inconvenience and heavy cost to both manufacturer and users of rails in having so many different sections led up to an effort toward adapting a series of what could be regarded as standard shapes. This task was undertaken some time in 1888 or 1889 by a committee appointed by the American Society of Civil Engineers. The work was taken up cautiously and met with a good deal of interference. But the committee persevered, and in course of three or four years brought out what is now known as the A. S. C. E. sections, which give a series of shapes varying by five pounds per yard from 50 lbs. to 100 lbs.

Notwithstanding the fact that some engineers have always criticized these sections, and many roads would never accept them for use, still the widespread advantage to be gained in having standard shapes led to their rapid adoption, and within ten years from the time they were introduced fully 70 per cent of all the rails rolled for American railroads were made of these patterns. At the present time, the proportion has increased to over 75 per cent.

One of the leading advantages to the manufacturer in the A. S. C. E. sections is in the distribution of metal in its different members.

	Per Cent.
In the head there is	42
In the web	21
In the base	37
	100

There is but five points difference between head and base, and these being so much closer than many of the sections, the mills were formerly required to make that they gave the A. S. C. E. sections a cordial welcome and have always tried to further their use.

At the time these patterns were designed and introduced an 80-lb. rail was regarded as a heavy section, and some engineers even doubted whether one so heavy could be used economically. The designers, however, evidently expected railroad track to grow, for they provided for 5 lbs. per yard increase in weight till 100 lbs. was reached, and then designed a 110-lb. pattern, apparently for good measure.

The period during which the 80-lb. rail was regarded as heavy was not of long duration, for the railroad soon took on 85-lb. and 90-lb. section and during the past few years a very considerable tonnage of 100-lb. rails have been made.

The 90-pound rail was an increase of about 12½ per cent and the 100-pound about 25 per cent over the 80-lb. The users of rails naturally looked for a proportionate gain in wear for the additional steel bought. But this did not always obtain and led to the criticism that they were not properly worked; that they were rolled too fast and finished too hot. An effort was then made to incorporate in standard specifications what was called a "shrinkage clause." By this is meant that the rails when they reach the hot saw shall be at such reduced temperature that only a certain number of inches and fractions of an inch shall be allowed for the rail to contract in length from the temperature at the sawing down to 70 degrees. It was expected that if the mills could comply with this, the steel would come through the finishing passes at a lower temperature, and the colder rolled steel would give better wear.

It would be perfectly reasonable to look for those results from such conditions. But the difficulty in incorporating a shrinkage clause in general specifications and making it operative was found in the fact that rails cannot be brought to the hot saws at the same temperature in every mill. There are no two in which the shrinkage could be kept exactly alike, therefore, any fixed allowance in a general specification could not be made applicable in all places.

The opposition to a definite shrinkage clause in specifications is raised on account of the insurmountable difficulties encountered in attempting to fix a temperature at which the finishing work shall be done in unbalanced sections.

As already stated, the A. S. C. E. section, or any other tee-rail thus far made, has greater percentage of metal in the head than in the base. The head is in a mass with less radiating surface than the base. The base is not only smaller, but thinner, besides having a greater radiating surface. It can, therefore, be readily understood why there is considerable difference in temperature between head and base, when the rail goes through the finishing passes. The object of a shrinkage clause was to improve the rail head by finishing at a lower temperature, but in an unbalanced section the base is likely to get too cold to work, or so hard as to cause damage of breaking rolls, while the head may still be hot enough to admit of some reduction. The impossibility of obtaining all that might be desirable from colder rolling in such shapes is quite apparent.

Cambering of the rails is made necessary to counteract the warping that takes place in cooling. The warping is due mainly to the shape of the section and the rail is rarely perfectly straight when cold. Whatever warp or crook that may be left in must be taken out by the cold straightening. This is done in a press under a slow motion plunger by applying pressure on the rail centrally between bearings forty-two inches apart. The arrangement of this press has lately become part of a general specification, and for that reason should receive some notice in this connection.

It is pretty generally conceded by both rail makers and users that the strain and torture that rails have to endure in cold straightening are the most severe and most objectionable work in the whole manufacturing and finishing process.

The impossibility of taking a bend or kink out of a rail without straining it beyond its sectional elastic limit makes the necessity of setting up internal stresses, working at cross purposes with the normally cold tension of the steel, unavoidable. To what extent these may be harmful to the rail after it is put into service cannot be definitely determined, but it is only reasonable to infer that they have some effect. The remaining work in finishing after the straightening is done consists of drilling, chipping, filing, etc., all simple mechanical or hand operations not likely to cause any injury.

The final action on the part of the railmaker with the intention of turning over to the railroad material sound and in good order, is to see that it is properly loaded, so that in unloading there will not be danger of undoing any of the finishing work accomplished with so much painstaking effort at the mill. At this point we pass to the third step, namely, how rails are used.

The way rails are used, and what happens when they are used, is so well known and understood by all men in any way associated with railroad business that it would seem hardly possible to say anything new on this part of our subject. But rail wear, or more particularly rail failure, which, at various times, has caused considerable general comment, necessarily occurs when they are in use and are of sufficient importance to arrest attention. Therefore, the use of rails, how they are treated, and what takes place under such treatment, should be studied and better understood.

When a rail goes into track it is placed on a series of wooden bearings, usually about 22-in. centers, and fastened at the end to adjoining rails laid in the same way. The wooden bearings rest on broken stone or gravel, and these in turn are carried on the natural earth of the railroad bank or cut, as the case may be, consisting of any grade material from light dry sand to heavy wet clay, and may be solid or unstable, depending on drainage and other local conditions. Thus we see that a railroad track is constructed somewhat in reverse order from other structures built to carry loads. That is to say, the steel rail, the strongest and most permanent member of the construction, is at the top while the soft earth or wet clay, the least stable part, is at the bottom.

The rail in service has been compared with a bridge and referred to as a continuous girder, which should be taken into account the same as girder members of a bridge, but there is so much difference in conditions under which these two girders work that there is hardly any comparison.

The bridge girder rests on fixed and permanent foundations, always holding the same position and carrying loads in the same way. On the other hand, a rail rests on a series of varying foundations, no two of which are exactly alike at any time, and always subject to differences effected by changes in seasons and climates.

The unstable or yielding track foundation is found very practicable in railroad operation, but the additional strains thrown into the rails in consequence therefrom are there nevertheless and should not be overlooked.

It is not an uncommon occurrence for a panel of rails in first-class track to carry a load upward of 200 tons over its entire length in half a second of time or less. This enormous weight coming on to the rails in such a short interval causes a shock almost equal to a hammer blow.

During this short space of time every foot of the rail throughout its entire section is subjected to alternating tension compression and torsion and the head to crushing and abrasion. There is not a piece of steel made for any structure whatever that has to withstand such severe treatment as that imposed on a rail.

Think for a moment what a rail is supposed to be, and what it is expected to do. It must be hard enough to withstand abrasion, elastic to spring without bending, ductile to stretch without breaking, and rigid enough to carry a load with little deflection.

In attempting to work all these qualities in a single composition, and afterward subjecting the material to the extraordinary impacts and strains that a rail receives in track, it is little wonder that some of them fail. It is rather more surprising that the number of failures are not greater.

The users contend that rails fail because of defective material or shortcomings on part of the manufacturers in the process of making.

The manufacturers claim that the users do not specify the grade of steel, nor weight of rail best suited to their various traffic and climatic conditions; that maintenance of way is not always what it should be; that bad order rolling stock and irregular operations of motive power are responsible for a greater part of rail destruction.

It is not possible to determine which party is exempt of fault, but a better understanding of failures will show that neither is wholly exempt.

There are nine or ten classifications of rail failures, but more than 95 per cent can be placed under less than half that number. The remainder are of rare occurrence and little account.

First are the head failures which are result of piping, or caused by the metal actually shearing off at the sides, usually about on line with one side of the web.

Piping, as already stated, is a defect inherent in the steel, and the whole responsibility for this rests with the manufacturing.

Every practicable precaution is constantly exercised against such material going into rails, but in spite of all that can be done, some with this defect get into use.

To reconcile the fact that piped rails are found, with the claim made that sufficient material is discarded from top of ingot to insure sound steel, it will be necessary to explain that piping in ingots is not confined entirely to the top, but does at times occur all the way down through the center, although it may not be continuous. Such piping will not show at the ends nor give any surface indication of its existence when rails are finished. It ordinarily develops under traffic and then appears by the head flattening or spreading out. Only a very small percentage of piped rails give out suddenly, or without first showing this condition on the head surface and affording time for removal before harm is done. Some railroad engineers pretend to say that they do not regard rails showing slight piping as particularly dangerous, and often allow them to remain in use after their condition is known. It is the opinion of the writer, however, that rails which show piping in any degree are wholly unfit for any main line track, and never should be allowed to remain in that service.

Split head failures occur on high curvature track and on the inside or low rail of the curves. These are apparently due to irregular bearings of worn wheels and cross strains thrust into the rail head by tread of false flanges, on extreme outside corner. This leverage brings the maximum stress at top of rail head, about on line with side of web, where such breaks are generally found.

Another type of failures resulting from rail and track conditions, similar to that just mentioned, is in the metal flowing or crushing off the corners of the head. The outside wheel of a truck passing around a curve, not only rolls but slips over the rail, and when the track gauge is wide, it slides across the head, causing the metal to flow or shell off in long, ragged strips. This kind of giving out is sharply criticised and often causes considerable anxiety among railroad engineers, on account of the seeming weakness. Such rails have an extremely bad appearance and ordinarily show excessive wear, but they are not unsafe to run over and may be retained in service without any unusual risk, until completely worn out.

By far the greatest number of failed rails are due to breakage, that is to say, complete fracture of the entire section. These are not only most numerous, but most dangerous to any in the whole classification.

There are three distinctive characteristics—breaks that may be described and in a measure accounted for as follows:

First—The square break in which the fracture is almost at right angle with the axes of the rail and is often quite as regular as a saw cut. The fractured surface may be fine, close, homogeneous texture, but the shape of the break indicates excessive hardening properties in the metal, bringing it close to the point of brittleness—hence, easily ruptured by shock and therefore poor quality steel for rails.

Second—The angular, or shearing break, which generally passes through the section at an angle of 45 degrees or less, with longitudinal axes. This shows that the rail stood a deflection and elongated before breaking, indicating ductility and a perfectly good grade of steel, but probably broken by severe shock or excessive overloading.

Third—The base break. There are more failed rails from breaks of this character than from any other cause. It is found in varying degrees on all railroads and in rails from all mills.

The principal peculiarity of this break is that it starts at the center of the rail base, directly under the web, and develops longitudinally, extending from 6 to 18 ins. and will then run out to the edge of the flange, resulting in a "half moon" or flange break, and in many cases also extending upward through the rail, causing a complete fracture of the entire section.

It is safe to say that in more than 90 per cent of rails reported by the railroads, simply broken, the failures originate, as above described, in the base, and more than 99 per cent of such breaks occur on ties.

These are actual conditions as found by investigation. How can they be explained?

The ordinary tee-rail, now of universal use in this country, has long been studied and tested, with the idea dominating that its merits should be considered chiefly, or almost entirely, as a girder reaching across short spans supported at the ends and loaded at the center. When it is found by calculation that the rail is strong enough, with a good factor of safety to carry the maximum load at the center between these bearings, the notion seems to prevail that all requirements have been determined. It is assured that no particular harm can befall the rail at its bearings, where the support is directly under the base.

This seems quite logical, as the load is always applied at the top; the base is properly shaped to sustain tensile strain and rests on foundations placed every few inches along its length. The spans are short, and it can be easily demonstrated that the average size rail has ample strength to carry enormous loads between these supports.

As a girder then the rail seems to be theoretically and practically correct in shape. But it has already been shown that the roadbed and ties, which constitute the rail foundation, are unstable and yielding and that the solidity of tie bearings is at times widely variable, making the bearing surface of the whole rail base quite irregular and uneven. These conditions are generally worse when roadbed is frozen.

In consequence, the base member of the rail section has, too, sustained excessive compressive strains at the higher or more solid points of its bearings.

The rail base in compression will, on account of its shape, buckle, drawing the edges of the flanges upward, thereby causing a cross strain with maximum tension at the center directly under the web, and this is the point when base break begins. Therefore, it appears that the base member of the tee rail girder as now made is deficient when subjected to compressive strain and for that reason fails.

This covers, in a general outlined description, the disagreeable and much to be avoided things that happen in the use of rails.

Failed rails, considered in the abstract, make an uninteresting subject and one that nobody cares much to discuss.

From the outside or dissociated viewpoint, they bode serious shortcomings on the part of some one.

Taken by themselves, whatever the quantity may be, it is always too large, but with the enormous tonnage from which they originate it becomes quite insignificant.

Steel rails of American manufacture on American railroads are today in the aggregate, of excellent quality and giving splendid service. The proportional tonnage in the whole country that seems to be wearing out too fast is not large. The failed rails all told are relatively small in quantity, constituting only a small fraction of 1 per cent of the tonnage made.

The loss in value of material to the steel companies or the railroads on this account is comparatively so little as to be almost negligible.

We get in public reports full and complete accounts of complaints made against rails not giving satisfactory wear and those that fail, but not much mention of the millions of tons in thousands upon thousands of miles of track that are meeting all expectations to the fullest degree, in matters of both service and safety.

But the effort for better wearing steel will go on, and pursuit of the ideal rail that will never fail still continue.

Just at the present time we seem to have reached one of the transition periods in the manufacture and use of steel rails, in which the rails as made do not quite balance with the railroad traffic as it exists in all places.

A correction must be found.

The manufacturer is held by certain limitations in character of raw materials that prevent meeting all that might be desirable in changes of composition of steel for the improvements needed.

The railroads cannot recede in the matter of heavy loads and fast trains, and must by some means get rails that will hold up to changed conditions as they are.

It is believed that a remedy can be obtained by the co-operation of the manufacturers and railroads in bringing out a revised rail section. This will embody certain cardinal principles and be designed with a view to overcoming detail deficiencies found in the present sections, at the same time for a better shape to roll.

It is suggested that, in comparison with the A. S. C. E. sections, both head and base should be re-enforced, and that the distribution of metal be nearly balanced, making that in the base equal or slightly greater than in the head. It is also proposed that width of base shall be less than height of rail, which will admit of forming thicker flanges.

The advantages of a balanced section, with comparatively thick base are:

First—Lower temperature of the whole section at the final pass—hence a colder finish of the rail head, giving denser and better wearing material.

Second—Less cambering and better hot straightening, reducing, as much as possible, the objectionable cold straightening work.

Third—A re-enforced head to provide against splits and other head failures.

Fourth—A re-enforced base to overcome the weakness that seems so prominent in present pattern rails.

It is expected also, that with this pattern rail the higher carbon steel from grades of ores now available may be made with safety, and by longer service prove a benefit to the railroads.

The balanced sections can be made easily and economically, and will thereby contribute to the interest of the manufacturers.

With such rails in track, the qualities of durability and security should gain confidence in their use, and redound to the welfare of that very important third party interested in good rails—the Traveling Public.

A sailing vessel built of concrete is in service at Baltimore, Md., according to press dispatches. The boat is a two-masted schooner yacht, 65 ft. long, with an 18 ft. beam and draws 14 ft. of water. The boat is said to be easy riding and in a breeze capable of outsailing wooden craft. The boat, which is owned by Daniel B. Banks, consulting engineer of the Baltimore Fire Board, has been as far north as the Hudson Bay country.

The total production of gold in Australia for the nine months ending Sept. 30, 1908, was 2,665,284 fine ounces, as against 2,709,346 fine ounces for the corresponding period in 1907.

Methods and Cost of Constructing T-Rail Track with Carnegie Steel Ties Utica & Mohawk Valley Ry.*

BY M. J. FRENCH†

Realizing the advantages of T rail over girder rail construction from both the maintenance and cost standpoint, the Utica & Mohawk Valley Ry. obtained permission this year to replace a piece of 9-in. tram-head girder double track on Bleecker street with 100-lb. Am. Soc. C. E. section T rail, laid on steel ties and paved with vitrified blocks. The girder rail removed was laid in 1902 on 6 ins. of crushed limestone and slag ballast. The ties were 6 x 8 in. sawed chestnut ties 8 ft. long, spaced 2 ft. on centers with suspended joints. No tie rods or brace plates were used. The track was filled with crushed slag. This track was going down at the joints, was at least ½ in. wide gage and considerably out of line at the joints. The 21-ton interurban cars operated on half-hour schedule and 19-ton city cars on 7½ minutes, with an occasional Oneida Ry. passenger car of 39 tons and express cars reaching a maximum of 65 tons when loaded, were cambering the rails and maintenance of schedule speed would have soon made uncomfortable riding. The T-rail construction was therefore decided upon to give relief.

As the total street distance to be improved was only 1,230 ft., with a permanent cross-over 800 ft. from the east end, we decided to place a portable cross-over at the west end and operate all cars on one track while rebuilding the other. Flagmen furnished by the Transportation Department and stationed at the cross-overs controlled the movements of the cars. The dead track was used to haul in the track and paving materials. A trench 12 ins. deep was excavated, leaving the stone and slag ballast of the girder construction undisturbed. On this sub-grade Carnegie steel ties 1¼ ins. high with 1-in. top and 6 in. bottom flanges, 7 ft. long and weighing 101.5 lbs. were placed 4 ft. on centers with two ties per joint 2 ft. centers. Joints were staggered and ⅜ x 2 in. tie rods were placed 8 ft. on centers with one 2 ft. from each joint to bring track to accurate gage. Clark joints were used. They consisted of the regular 36-in. angle plates with 13/16 in. holes spaced for drilling 2½ x 6 x 7 ins. from rail end to allow for tie clip. The lower flange of joint plate was sheared off so as not to project beyond rail base and the plates were slotted to receive steel tie clips. Joints were bolted up temporarily with two 1⅛ in. bolts, drift pins being used to bring the holes in plates and rails accurately into line. The 13/16 in. holes were reamed to 1 15/64 in. with Ludlow adjustable reamers operated by hand in a Cleveland electric drilling machine. The motor of this machine could not be used and consequently the reaming of each hole cost about 6½ cts. instead of about 1 ct. if motor driven. Six 1¼ x 1¾-in. square head, hexagonal nut bolts 1/64 in. larger than the holes were driven into the holes. These were special bolts with threads 1⅜ in. long to give full body of bolt in hole of plate. The track was surfaced on blocks cut from old wooden ties, being raised with jacks slightly above grade in sections of 100 to 200 ft. and brought to surface by driving down the blocks with a heavy sledge. Trenches 6 ins. deep and 18 ins. wide were dug under steel ties and ties were tamped up with 1:3:6 mixture of slightly damp concrete. Concrete of same mixture was placed 1¼ ins. over ties at centers, with a crown of ½ in., the surfacing blocks being removed as the work progressed. A space about 1 in. deep was smoothed out under the rails and after 24 hours this space was filled and solidly tamped with a mixture of 1 part cement to 4 parts coarse quartz sand slightly moistened to insure packing. The track was lined after surfacing and carefully touched up immediately after concreting, all bar holes and spaces in the concrete being carefully tamped. Regular paving blocks were laid flat under the rail head to form a tram and were tamped by hand with a mixture of 1 part cement to 4 parts sand, these blocks being cut to fit over tie clips and at tie rods. The rest of the labor of paving and grouting was done by contract at 17 cts. per sq. yd. The tram bricks were omitted at joints, the space around the bolts being filled with grout when the pavement was grouted. The pavement between rails of each track was crowned ½ in., being flush with tops of rails at the center. The paving was kept ¼ in. below rail head along the back of rail head to prevent chipping by worn overhanging treads.

The total length of single track constructed was 2,160 ft. and the cost of materials per lineal foot of track was as follows:

Crushed stone figured as all new stone	$[illegible]
All stone used was screened from excavated material	
Concrete sand (labor only given in labor items)	[illegible]
Portland cement for concrete at $1.[illegible] per bbl	[illegible]
Steel ties complete with clips and bolts, $1.66 ea.	[illegible]
T rail 100-lb. Am. Soc. C. E. $[illegible] per gr. ton 60 ft. length	[illegible]
Clark Jt. plates per pair sheared and slotted, $1.15 ea.	[illegible]
Joint bolts 1¼x1⅝ ins., each [illegible] cts	[illegible]
Tie rods ⅜x2 ins. x 5 ft. [illegible] .26½ cts.	[illegible]
Track inlets with connections, Syracuse type, $8.75 ea.	[illegible]
Thermit 8 lbs. per joint at [illegible]	[illegible]
Welding supplies, crucibles, [illegible] etc.	[illegible]
Paving sand 1 cu. yd. to [illegible] ft. of track at $0.63	[illegible]
Paving blocks [illegible] per sq. yd. [illegible] $25.00 per M	[illegible]
Portland cement for grouting and flushing mixed 1 [illegible] 20 lin. ft.	[illegible]
Total cost of material per ft. of track	$[illegible]
Add 10 per cent for use of tools and power	[illegible]
Total cost for materials, tools and power	$[illegible]

The actual labor cost per lineal foot of track was as follows:

Excavation with [illegible] per cu. yd.	[illegible]
Hauling old material to storeyard	[illegible]
Delivery of track material	[illegible]
Track laying, including drilling [illegible] and placing tie rods	[illegible]
Delivery of concrete materials, including loading of sand at [illegible] and hauling [illegible]	[illegible]
Concreting track to pavement grade [illegible] cu. yd.	[illegible]
Placing track inlets per basin, $[illegible]	[illegible]
*Placing Clark joints, reaming and bolting up	[illegible]
†Welding joints, including making of molds and crucibles	[illegible]
Delivery of paving materials, sand, cement and blocks	[illegible]
Street paving, puddling, grouting and rail batter, or [illegible] per sq. yd.	[illegible]
Cleaning up street, including hauling of surplus screened stone and fine screenings, grading lawns, cleaning sidewalks, etc.	[illegible]
Watching and timekeeping	[illegible]
**Flagmen and switchmen	[illegible]
Superintendence, engineering and inspection	[illegible]
Total cost of labor per foot of single track	$1.[illegible]

*Cost per joint 68 cts.; if holes had been reamed by electric power cost would have been [illegible] cts.

†Cost per joint 97 cts., including four combination joints.

**Two flagmen from Transportation Department at 21 cts. per hour and one switchman at 15 cts. per hour, 20 hrs. per day.

The cost of screening stone used for concrete was 5.7 cts. per ft. of track but is not included as labor because stone is figured in material cost as new stone. The total cost per ft. of track, with 5 ft. center strip and 25 ins. of pavement outside of outer rails, is $5.106.

The cost of labor on 9-in. tram head girder construction on Whitesboro street in 1907, maintaining operation of cars and employing the same type of steel tie construction with vitrified block paving was $2.19 per ft. of single track. This construction was done under the same conditions as to maintenance of traffic and the same cars were operated with the exception of the Oneida Railway cars. The same type and size of steel tie was used as on Bleecker street this year, but the spacing was 6 ft. on centers, the concreting methods were identical but all joints were thermit welded. The excavation included removal of asphalt pavement and concrete base outside the rails of a single track paved with cobbles. The itemized labor cost per lin. ft. of single track was as follows:

Placing and removing temporary track per lin. ft.	$[illegible]
Excavation including hauling per cubic yard, partly concrete, $1.[illegible] or per ft. of track	[illegible]
Hauling away old materials, including old rails, wooden ties, scrap, old paving materials and cobbles per ft. of track	[illegible]
Delivery track materials per ft. of single track	0.01
Track laying and surfacing per ft. of single track	0.19
Delivering concrete materials, including loading and hauling of sand [illegible] miles by work train and breaking of old concrete and stone for use in new concrete per ft. of single track	[illegible]13
Concreting, including dry mixture under ties and under rail bases, per cu. yd. $[illegible] or concreting per ft. single track	[illegible]
Placing track basins, two basins being located every [illegible] ft. of single track	

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*Paper read before the New York State Street Railway Association Nov. 10, 1908.

†Engineer Maintenance of Way, Utica and Mohawk Valley Ry., Utica, N. Y.

price per basin $8.64 or per ft. of track	0.02
Thermit welding, including labor on moulds and crucibles, per joint $1.24, per ft. of track	0.04
Delivery of paving materials, including loading of blocks at storeyard per ft. single track	0.11
Cleaning up street, including removal of unused materials, broken bricks, and regrading of lawns, between sidewalk and curb, per ft. of track	0.06
Flagmen and switchmen per ft. of single track	0.01
Engineering, supt., and inspection, not including time of foreman, per ft. of single track	0.09
Brick paving, per ft. of track	0.21
Timekeeping and watching	0.05
Total cost of labor per ft. of track, including paving	$2.19

The total labor cost was thus 58.4 cts. per ft. or 36 per cent greater than that of the Bleecker stret T-rail construction. A considerable saving on materials is evident as 3 ins. less of excavation and concrete materials are required and the cost of rails is $4.60 per gross ton less.

This year we have laid on Mohawk street 6,985 ft. of this same 9 in. tram-head rail, Lorain Co. section 95, No. 297, with 763 ft. of special work track. The type of construction was the same as that on Whiteboro street except that Clark joints were substituted for thermit joints and the joints were placed opposite as an experiment. Two steel ties were placed at the joints and the last upper joint holes were used for tie rods. As the rails were already drilled with 1¼- in. holes for regular 12 bolt joints with 1-in. button head bolts, we used 1 5/16-in. bolts in order to secure the driven fit, ten bolts to a joint. The details of labor cost per ft. of single track are as follows:

Temporary track	$0.0105
Excavation	0.3186
Track laying	0.2150
Delivery of track material	0.0700
Delivery of concrete material	0.1376
Delivery of paving	0.0952
Timekeeping and watching	0.0572
Engineering	0.0888
Clark jts., placing and reaming	0.0386
Welding	0.0226
Bonding specials	0.0289
Concreting track	0.4344
Drains and sewers	0.0067
Cleaning up street	0.0664
Brick paving	0.1914
Hauling old materials	0.0025
City inspector	0.0204
Total per ft. of single track	$1.805

Compared with the Whitesboro street construction of $2.19 for labor there is a saving of 38.5 cts. or 21 per cent. It is quite evident that this saving is due to the fact that there was no car traffic to be maintained and that the first track constructed could thus be used for delivery of materials.

Plans and specifications for an extension system of irrigation for Porto Rico have been prepared by B. M. Hall, Chief Engineer of the Porto Rico Irrigation Service, and have been submitted to the Director of the U. S. Reclamation Service. An examining board composed of engineers of the U. S. Reclamation Service will soon go to Porto Rico to report on the project. The legislature of Porto Rico has provided a $3,000,000 bond issue for the work.

LETTERS TO THE EDITORS.

The Reason for Slow Progress and High Cost of the Panama Canal Work.

Sirs: I have read the various articles in your paper in reference to the actual cost of the Panama canal work in proportion to the estimated cost, the slow progress made, the advisability of letting the work by contract, etc. I have also noticed in many different papers, explanations as to what the trouble is, why better progress cannot be made, costs kept lower, and head employees kept at the undertaking.

As it has appeared to me that the principal trouble with the existing conditions has not been clearly stated by these articles, I desire to state the conclusions arrived at by myself when visiting the work in the winter of 1906 and 1907. This trip was made just for fun and to see what was doing, and no effort was made to spot any troubles or to get the whys and reason of the then existing conditions, (which any one familiar with construction work could not help but see were all wrong to get fast results or at minimum cost), except as such reasons became apparent without butting into the other fellow's job and duties.

I found, so far as I was able to see, with the exception of passenger and baggage traffic on the Panama Railroad, (which was one of the rankest steals by employees that ever came to my notice, barring only the olden days of the first operation of some of the transcontinental lines when the superintendents openly sold jobs to the conductors with full privilege to plunder the road for a given time), an honest and very efficient body of employees from the chief engineer down to and including the train and shovel crews, foremen, and even laborers, considering the class of laborers necessarily used. They were sober, industrious, interested in their work, generally satisfied with conditions so far as the same affected their health, comfort and compensation, but with the feeling, among those possessed of capacity and energy, of no opportunity to do. The cause was not to any great extent the red tape of ordering, buying, delivering and getting hold of materials, or the requirements and restrictions of reports, rules, orders, etc., which go with government work. The cause, as it appeared to me, was that no one man or body of men with ability, and knowledge of their undertakings, were at liberty to plan and do that which was necessary for rapid and economical construction of the canal upon the general plans adopted. The result was that big men, who could do, pulled out; others settled down to existing conditions and chafed more or less because of them, while the easy-going fellows, who could be pushed in most any direction by the forces behind them, accepted the work as it was, recognized it as a Government job that of course could not be run as it best be, or as the big fellows had been used to and would like to do it.

The foundation of the trouble in the carrying on of the construction work was, I believe, the buying by the United States of the old plunder and scrap iron designated as machinery equipment, etc., from the French company. No doubt it was advisable and necessary to buy it, along with the rights secured, but to get the trade through and Congress to let go of the money, it had to be and was represented that we were getting something of value and suitable for use in the carrying on of the construction work, where as a matter of fact, with the possible exception of some of the dredges, we were getting nothing but worthless scrap, which, when new, was of no value for the carrying on of the work. It never would have been put in use by those in charge of the construction work except that there it was, bought at great expense upon the representation to the public that it was fit to use, and it had to be used, notwithstanding the fact that every one capable of judging knew it better all be in the dump where thousands of tons of it went as fast as allowable.

All this French equipment was 5 ft. gage. So in place of laying the track to standard gage and getting new equipment of standard gage, all new equipment had to be made to fit so that the old plunder could be used.

The land excavation and every proposed method of the French for handling the dry excavations were so absurd and impossible of successful operation that many steam shovels of adequate capacity were quite early secured, but no means provided for taking the material away from the shovels, with the result that the shovels were idle fully two-thirds of the time. I have a hundred different times stood in Culebra cut, where from six to fifteen shovels could be seen at the same time, and never found to exceed one-half of them at work at the same time, and usually not to exceed one-fourth of the number in sight in operation, and they were nearly always idle for the same reason, no cars supplied. And this was in the dry season when there was no rain to interfere with operations.

Occasionally a shovel would get a string of little dump cars, about as many as a good Irish mule would handle in the States, under favorable conditions, with two built-over Belgium engines hitched to them that would keep the shovel busy from 10 to 30 minutes, and occasionally a train of American flat cars with an American engine that would show the work the shovels could do if given an opportunity.

Now, the lack of train service and unnecessary number of shovels kept in operation was not because those in charge did not know that such was not the way to economically and quickly build a canal, but because they could not get the necessary equipment because of the necessity to use the old French truck that had been represented to be such a bargain when bought, and because the number of steam shovels in use had to be employed and kept in operation to satisfy the demands that the work be pushed.

Now, these were the conditions under which the Government did and had to proceed with the work. No contractor, no private corporation, would have been under such obligations, and it was just as much a mistake for the Government in the first place to have undertaken to decide on the equipment, etc., needed for doing the work as it was to undertake to do it, for even though the Government agents were free to use their best judgment, it is very doubtful if their experience and judgment were sufficient to enable them to determine as to the best methods and means.

A railroad company or other corporation or person undertaking extensive construction work does not attempt to determine for the contractors the means, methods, and appliances by which he shall carry on his work, or to buy such appliances for his use, any more than they undertake to employ men to do the work on their own account. There is no doubt that contractors would have come to the front, if given the opportunity, who would have provided all equipments, etc., required purchased for much less money than the Government has by its methods been able to purchase it, and of a kind and used by methods and under management all free to their own control, to have done all that the Government wanted done at about double the speed it has or will be done and at two-thirds the cost or less, and this, not because of the incompetency of those in charge, but because: 1st, those in charge never were and are not now free to act on their own judgment; 2d, because the methods and proceedings of a contractor cannot safely and successfully be used by a Government; 3d, because the field of ingenuity and resourcefulness has not been drawn upon in the Government proceedings as it would have been by undertaking the work under contract.

Now, as an example of how the Government representatives have been and are tied up to public opinion and the "butting in" of those who know little or nothing about the propositions passed upon, take notice of the design upon which it is proposed to construct the Gatun Dam, conceded by those in charge from the first to be a waste of money and time, because of unnecessary width and height and many other unnecessary features, looked upon by those in charge at Panama, from the Division Engineer up to the Chief, as being a foolish and unnecessary piling up of material. Yet there is no way to help it, and prospects from the present uncalled for agitation are to have millions more of money and years more in time tied up in unnecessary work, only because those in charge are not in charge of anything, and never were and never will be.

These are the conditions under which a Government must proceed with its undertaking. Therefore, make the Government's undertaking as light as possible, and let the independent operator do that which can so much better, quicker and cheaper be done by him.

But it has been urged that the work as a whole was too big for any contractor, especially so if he were to undertake to supply his own machinery, equipment, etc. While this is not a fact, and while means could easily have been devised for the Government to have financed the proceedings so far as was necessary in the purchase of plant, etc., yet there was never any necessity of letting it as an entire contract, and the argument of the necessary use of the Panama Railway is the weakest of the arguments offered. There never was any use for the railway in the actual construction work and it had better never have been made use of, as is conceded by many of those in charge of the work.

There never was any more difficulty in dividing the work up into a dozen or twenty contracts, than in many pieces of railway construction and other undertakings elsewhere, and there is no difficulty in doing so now and letting the work at fixed prices per yard or other measure.

One need stay on the Isthmus but a few days to see how little different the conditions are there from any other place where work is to be done. There is no more sound argument in the claim of unknown conditions, uncertainty as to kinds of material, etc., on the canal work than in the Rocky Mountains, or many other places where contractors do not hesitate to back their own judgment, and have almost without exception succeeded at their undertakings.

Has there not already been time and money enough wasted in getting just started at the work?

Have not the Government employes enough on their hands in determining as to what is to be built and compromising between their own knowledge and judgment and the cry of the press and other interferences, to keep them busy and give credit for their faithful services without undertaking to do that which no Government can successfully do and continue in an effort to manage that which has so far failed, both as to time and cost, and will continue to fail to the end, not because of incompetency or unfaithfulness of the Government agents, but because of their lack of opportunity, and because the world's ingenuity and resourcefulness has not been, is not being, and will not be called on in the undertaking.

I expect to make another trip to the Isthmus in February. If I find present conditions so much different from those at the time of my former trip as to justify I will write my apology from there.

Yours very truly,

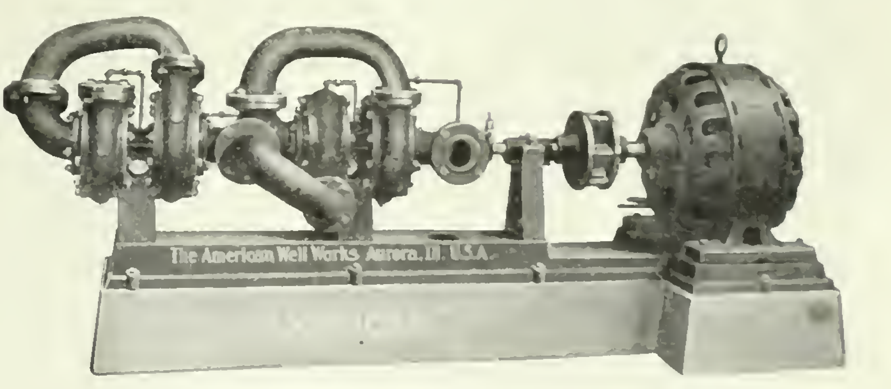
C. L. Bartlett, C. E.

Cedar Rapids, Iowa, Jan. 5, 1909.

A New Type of Centrifugal Pump.

A multiple stage centrifugal pump of a new type that the makers, the American Well Works, Aurora, Ill., assert develops higher efficiencies than any centrifugal before introduced is shown in the accompanying illustration.

Plain centrifugals made by this concern have an impeller machined on both sides and edges to the exact size of the volute with a closely adjusted cut off at the entrance of the discharge pipe. These features make it impossible for water to pass the outlet and be repumped as the clearance between the impeller and the casing is only about 1-64 in. and this forms a seal against the passage of water. Another feature of these pumps is that the intake and discharge is by means of long pipe bends so constructed that there is no sudden change of direction of the water when passing through the pump, thus reducing friction to the minimum.



Multiple Stage Centrifugal Pump.

In the multiple stage pump the stages are placed close together, to shorten the shaft. The connections between the stages, however, are large pipe bends of increasing diameter and radius, so designed that a constant expansion is allowed to the flow without sudden change of direction, which reduces the skin friction to the minimum.

The single-stage types of these pumps operate against total heads up to 125 ft., the two-stage up to 250 ft., the four-stage up to 500 ft., with corresponding increase in heads for additional stages. Efficiencies of 60 to 80 per cent. are claimed for these pumps, depending upon the size and working conditions. A recent engineer's test of a 3-in., four-stage centrifugal of this design, pumping from an enclosed pit and therefore not operating under the most favorable conditions, delivered 460 gallons of water per minute to a total head of 440 ft. and maintained an average efficiency of 65 per cent. This pump was designed to deliver only 280 gallons per minute.

It is claimed that the ability of these pumps to operate against high heads especially adapts them for mine pumping and fire protection service. All bearings in the water end of shaft are fitted with automatic hydraulic lubricators, and the pumps, therefore, require little attention when in operation.

As a result of the recent cholera epidemic at St. Petersburg, Russia, the municipality is now considering the question of supplying the city with water from Lake Lagoda, one of the finest fresh-water lakes in the world. The water is pure and the supply inexhaustible. The altitude of the lake is sufficient for supply by gravitation, and the plan, if carried out, will prove of great value to the city. This lake is situated about nine miles from St. Petersburg and is the source of the river Neva.

Cost of Setting Water Meters and Laying Service Pipes.

BY W. H. SHILLINGLAW.*

The cost of setting water meters during 1908 by the Water Works Department, Brandon, Manitoba, was as follows:

Crown meters	⅝ in.	¾ in.	1 in.	1½ in.
No. of meters set	499	20	5	2
Cost of labor	$295.85	$20.55	$5.97	$2.60
Average cost per meter	0.593	1.02	1.20	1.30
Cost of materials	145.73	10.24	1.84	
Average cost per meter	0.282	0.51	0.37	
Total average cost per meter	0.875	1.53	1.57	

These meters were all set in basements by day labor by city employes. The cost for ⅝-in. meters varied from 20 cts. to $2 for labor. A large number of these meters were installed on old services and entailed considerable alteration in service pipes and additional expense. The cost of setting meters on new services varied from 20 cts. to 50 cts. for labor.

CITY ENGINEER'S OFFICE.

Brandon, *June 23*, 190*8*.

I beg to report the following labor and material used in

instaling. / repairing ....*New Service* ..... for Premises....

No ...... *16th* .... Street

for Mr. *Giddings & Wyman*. Ser. No. *1162*........

Installed by *Walker*....

Labor		*13½* hrs. at *25*	$	*3*	*.37*
		59 hrs. at *17½*	$	*10*	*.32*
Length of trench		*44* ft.			
Materials					
	44 ft.	in. *½* lead pipe	$	*6*	*.16*
	ft	in. lead pipe			
	ft.	in. iron pipe			
	ft.	in. iron pipe			
	1	*½* in. Corpin Cocks			*.99*
	1	*½* in. Kerb Cocks		*1*	*.85*
	1	Service Box		*1*	*.87*
		in. Unions			
		in. Elbows			
		in. Check Valve			
½ in. Lead Pipe—6 lbs. per yd.					
¾ in. Lead Pipe—10 lbs. per yd.					
			$	*24*	*.56*

Signed *Wm. Smith, Per R. M.*.............Foreman

Blank for Reporting Cost of Setting Water Meters.

The cost of laying water service pipes during 1908 was as follows:

	½ inch.	¾ inch.
No. of services	92	7
No. of feet laid	3,051	290
Cost of labor	$1,030.73	$ 96.69
Average cost per ft	0.34	0.333
Average cost per service	11.38	13.81
Cost of supplies	857.38	121.90
Average cost per service	9.32	17.41
Average length of service, feet	33	41

These services were laid in 10-ft. trenches in sand, gravel, clay, some dry and a considerable number very wet and requiring pumping. Refilling was well rammed. The cost of labor includes making up service, tapping main, etc. All work was done by day labor by city employes. The cost of labor varied from 26 to 50 cts. per lin. ft. The ¾-in. services were all made up for two ½-in. branches to serve two premises.

The form employed for reporting costs is shown herewith; this form was used for both services and meters, the foreman simply filled in the proper words.

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*City Engineer, Brandon, Manitoba.

Catalogs Worth Having.

Engineers and contractors should have on file the latest catalogs of machines, tools and supplies that they use. In sending for catalogs reviewed or advertised in this paper, you will confer a favor on us if you will write direct to the advertisers and state that you saw the catalog mentioned in ENGINEERING-CONTRACTING. If you are in the market for tools, machinery or supplies, tell us and we will notify promptly the leading manufacturers.

No. 1050. **The Largest Steel and Iron Warehouse in the World.**—Joseph T. Ryerson & Son., Chicago, Ill.

This pamphlet presents excellently the claim of its publisher to be the department store for the iron and steel consumer. It describes the firm's new and increased warehouse facilities for the storage of merchant and structural steel and outlines the variety of stock carried, the shipping facilities, etc. These descriptions are really informing. Incidentally the pamphlet is as handsome an example of press work and illustration as one often sees.

No. 1051. **Concrete Machinery.**—The Miles Mfg. Co., Inc., Jackson, Mich.

This pamphlet describes and illustrates the Miles block machine and gives directions for its operation and for mixing, molding and curing blocks of all kinds. Numerous patterns of face plates are shown. Besides block and brick machines the firm handles cement workers' tools, rock crushers, hoists, wall plugs, etc., which are also described and illustrated.

No. 1052. **Grub and Stamp Machines.**—Milne Mfg. Co., Monmouth, Ill.

This 106-page pamphlet illustrates and describes a variety of machines for grubbing, stump pulling and clearing timber, lands. Besides the straight catalog matter there is a large amount of useful information relating to the use and operation of the machines, methods of clearing land and moving buildings, etc.

No. 1053. **Steam Turbines; Centrifugal Pumps.**—D'Olier Engineering Co., New York.

Two leaflets, one illustrating and describing steam turbines for direct connected and belted service and the other giving similar information concerning the company's horizontal centrifugal pumps.

No. 1054. **The Belt Conveyor.**—By C. Kemball Baldwin, Robins New Conveyor Co., New York and Chicago.

This 24-page pamphlet contains a reprint of a paper read before the American Society of Mechanical Engineers. It describes the belt conveyor structurally in all its details, gives the steps in its development, discusses computation of power consumption, conveyor arrangements, and a variety of other practical matters.

No. 1055. **Concrete Fence Posts.**—Electrical Cement Post Co., Lake City, Iowa.

This pamphlet describes the construction, use and advantages of concrete posts for fences. This post construction has been very completely worked out and will interest many. The same firm also handles a block machine and molds for making cement drain tile and both are fully described and illustrated.

No. 1056. **Kerosene and Gasoline Traction Engines.**—Kansas City Hay Press Co., Kansas City, Mo.

The gasoline and kerosene traction engine described in detail in this 16-page pamphlet has been carefully worked out mechanically and contractors will be interested in its construction and operation as described.

No. 1057. **Stump Puller.**—R. S. Caward, Cresco, Iowa.

This catalog describes and illustrates the Faultless stump puller and the Faultless grubbing machine. The catalog is unusually good in its description of how to operate the machine to get the best results and for the hints which it gives for clearing and grubbing operations. Prices, capacities and other catalog data are given in detail.

CONTRACT NEWS

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We shall welcome any news notes that our readers may send in. Notes of contracts awarded, bidding prices, etc., will be especially acceptable.

BIDS ASKED

Bridges.

Bids Open.		See Issue.
Jan. 20.	Toledo, O.	Jan. 6
Jan. 20.	Chicago, Ill.	Jan. 13
Jan. 22.	Cincinnati, O.	Jan. 6
Jan. 22.	Madison, Va.	Jan. 20
Jan. 25.	Walkerton, Ont.	Jan. 20
Jan. 25.	Auburn, Ont.	Jan. 20
Jan. 25.	Akron, O.	Jan. 20
Jan. 28.	Cedar Rapids, Ia.	Jan. 13
Jan. 29.	Cincinnati, O.	Jan. 6
Jan. 29.	Cincinnati, O.	Jan. 13
Jan. 30.	Beaufort, N. C.	Jan. 6
Jan. 30.	Dayton, O.	Jan. 20
Feb. 1.	Topeka, Kan.	Jan. 20
Feb. 2.	Kingman, Kan.	Jan. 20
Feb. 1.	Greenville, Miss.	Jan. 20
Feb. 5.	Cincinnati, O.	Jan. 20
Feb. 6.	Mena, Ark.	Jan. 20
Mar. 4.	Paris, Ark.	Jan. 13

Buildings.

Jan. 20.	Springfield, Mass.	Dec. 23
Jan. 20.	Fort Robinson, Neb.	Dec. 30
Jan. 20.	Kansas City, Mo.	Jan. 13
Jan. 20.	Fort Robinson, Neb.	Jan. 13
Jan. 21.	Fort Crook, Neb.	Dec. 30
Jan. 21.	Fayetteville, N. C.	Jan. 20
Jan. 22.	Wabash, Ind.	Jan. 20
Jan. 23.	Anderson, S. C.	Dec. 30
Jan. 23.	Portland, Me.	Dec. 23
Jan. 25.	Jacksonville, O.	Jan. 13
Jan. 25.	Washington, D. C.	Jan. 20
Jan. 26.	Tomah, Wis.	Jan. 20
Jan. 27.	Fort Leavenworth, Kan.	Jan. 6
Jan. 27.	Pittsburg, Pa.	Jan. 20
Jan. 27.	Baltimore, Md.	Jan. 20
Jan. 28.	Ames, Ia.	Jan. 6
Jan. 29.	Vancouver Barracks, Wash.	Jan. 20
Feb. 1.	Regina, Sask.	Jan. 20
Feb. 1.	Claremore, Okla.	Jan. 6
Feb. 1.	Parkersburg, W. Va.	Jan. 13
Feb. 1.	Midland, Texas	Jan. 13
Feb. 1.	Newcastle, Ind.	Jan. 13
Feb. 1.	Los Angeles, Cal.	Jan. 13
Feb. 1.	Columbus, O.	Jan. 20
Feb. 1.	Cleveland, O.	Jan. 20
Feb. 4.	San Antonio, Texas	Dec. 30
Feb. 4.	West Durham	Jan. 20
Feb. 6.	Welch, D. Va.	Jan. 20
Feb. 8.	Columbus Barracks, O.	Jan. 20
Feb. 9.	Fort Myer, Va.	Jan. 20
Feb. 9.	Athens, O.	Jan. 20
Feb. 10.	National Soldiers' Home, Va.	Jan. 20
Feb. 10.	Stanford, Ky.	Jan. 20
Feb. 11.	Dulce, N. Mex.	Jan. 13
Feb. 11.	Clarinda, Ia.	Jan. 13
Feb. 11.	Madisonville, Tenn.	Jan. 20
Feb. 15.	Grand Rapids, Mich.	Jan. 13
Feb. 15.	Shenandoah, Ia.	Jan. 13
Feb. 15.	Fort Dupont, Del.	Jan. 20
Feb. 15.	Grand Rapids, Mich.	Jan. 20
Feb. 16.	Washington, D. C.	Jan. 20
Feb. 17.	Redfield, S. D.	Jan. 20
Feb. 17.	Salisbury, N. C.	Jan. 20
Feb. 18.	Greenville, Miss.	Jan. 20
Feb. 20.	Bar Harbor, Me.	Jan. 20
Feb. 27.	La Salle, Ill.	Jan. 13
Mar. 1.	Omaha, Neb.	Jan. 6

Roads and Streets.

Jan. 20.	Marion, Ind.	Jan. 6
Jan. 20.	Baltimore, Md.	Jan. 13
Jan. 20.	Chicago, Ill.	Jan. 13
Jan. 21.	Akron, Ohio	Jan. 13
Jan. 22.	Cincinnati, O.	Jan. 6
Jan. 22.	Wabash, Ind.	Jan. 20
Jan. 25.	Chatham, Va.	Jan. 20
Jan. 25.	Nottaway, Va.	Jan. 20
Jan. 26.	Annapolis, Md.	Jan. 13
Jan. 26.	Anderson, Ind.	Jan. 13
Jan. 30.	Cleveland, O.	Jan. 13
Feb. 1.	Olympia, Wash.	Dec. 23
Feb. 1.	Olympia, Wash.	Jan. 20
Feb. 1.	Moorhead, Minn.	Jan. 20
Feb. 1.	Greenfield, Ind.	Jan. 20
Feb. 1.	Wabash, Ind.	Jan. 20
Feb. 1.	Vevay, Ind.	Jan. 20
Feb. 1.	Fowler, Ind.	Jan. 20
Feb. 1.	Delphi, Ind.	Jan. 20
Feb. 1.	Decatur, Ind.	Jan. 20
Feb. 1.	Columbus, Ind.	Jan. 20
Feb. 2.	Crawfordsville, Ind.	Jan. 20
Feb. 2.	Vincennes, Ind.	Jan. 20
Feb. 2.	Valparaiso, Ind.	Jan. 20
Feb. 2.	Paoli, Ind.	Jan. 20
Feb. 3.	Cleveland, O.	Jan. 6
Feb. 3.	Bluffton, Ind.	Jan. 13
Feb. 3.	Kokomo, Ind.	Jan. 20
Feb. 4.	Frankfort, Ind.	Jan. 20
Feb. 4.	Frankfort, Ind.	Jan. 20
Feb. 5.	Lebanon, Ind.	Jan. 13
Feb. 5.	Anderson, Ind.	Jan. 13
Feb. 5.	Cincinnati, O.	Jan. 20
Feb. 11.	Appleton, Wis.	Dec. 30
Feb. 18.	Spencer, Ind.	Jan. 20

Sewers.

Jan. 20.	Toledo, O.	Jan. 13
Jan. 21.	Guthrie, Okla.	Jan. 13
Jan. 21.	Sylvania, O.	Jan. 13
Jan. 21.	Parkersburg, W. Va.	Jan. 20
Jan. 22.	Louisville, Ky.	Jan. 6
Jan. 25.	Purcell, Okla.	Jan. 6
Jan. 25.	Park, Tenn.	Jan. 20
Jan. 25.	Youngstown, O.	Jan. 20
Jan. 27.	Brooklyn, N. Y.	Jan. 20
Feb. 1.	Moorhead, Minn.	Jan. 20
Feb. 8.	College Hill, O.	Jan. 20
Feb. 17.	East St. Louis, Ill.	Jan. 20

Water Supply.

Jan. 20.	Augusta, Kan.	Jan. 13
Jan. 21.	Fort Hancock, N. J.	Jan. 13
Jan. 22.	Falls City, Neb.	Jan. 20
Jan. 22.	Donovan, Ill.	Jan. 20
Jan. 25.	Daytona, Fla.	Jan. 6
Jan. 25.	Waukesha, Wis.	Jan. 20
Jan. 29.	Carlyle, Ill.	Jan. 13
Feb. 1.	Denison, Ia.	Jan. 6
Feb. 1.	Avonmore, Pa.	Jan. 20
Feb. 2.	Hugo, Okla.	Jan. 20
Feb. 4.	Minot, N. Dak.	Jan. 20
Feb. 5.	Key West, Fla.	Jan. 6
Feb. 5.	Key West, Fla.	Jan. 13
Feb. 15.	New Ulm, Minn.	Jan. 20
Feb. 15.	Sebree, Ky.	Jan. 20
Mar. 15.	Wichita, Kan.	Jan. 20

Miscellaneous.

Jan. 20.	Boston, Mass.,	Refuse Disposal,	Dec. 30
Jan. 21.	Detroit, Mich.,	Wooden Tug,	Dec. 30
Jan. 21.	Boston, Mass.,	Cleaning Catch Basins,	Jan. 20
Jan. 22.	Fort Sam Houston, Tex.,	Steel Cells,	Jan. 13
Feb. 5.	St. Louis, Mo.,	Street Lighting,	Jan. 13
Feb. 6.	Boston, Mass.,	Wreck Removal,	Jan. 20
Feb. 8.	Prescott, Ariz.,	Fence,	Jan. 13
Feb. 11.	Mobile, Ala.,	Pontoons,	Jan. 20
Feb. 12.	Milwaukee, Wis.,	Concrete Caissons,	Jan. 20
Feb. 13.	Hawaii,	Dry Dock,	Dec. 9

Excavation, Earth and Rock

Jan. 20.	Rector, Ark.,	Ditch Work,	Jan. 6
Jan. 23.	New London, Conn.,	Dredging,	Dec. 30
Jan. 23.	Greenville, O.,	Ditch Work,	Jan. 20
Jan. 25.	Shamokin, Pa.,	Tunnel,	Jan. 13
Jan. 25.	Winchester, Ind.,	Ditch,	Jan. 20
Jan. 27.	Crookston, Minn.,	Ditch Work,	Jan. 6
Jan. 30.	Sterling, Ill.,	Ditch Work,	Jan. 13
Jan. 30.	Velasco, Texas,	Drainage Work,	Jan. 20
Feb. 1.	Sioux City, Ia.,	Ditch Work,	Jan. 6
Feb. 5.	Girard, Ill.,	Tile Ditch,	Jan. 20
Feb. 6.	Atkinson, Ill.,	Ditches,	Jan. 20
Feb. 10.	Logan, Ia.,	Ditch Work,	Jan. 6

Materials, Machines, Supplies, Tools, Etc.

Jan. 20.	Grand Island, Neb.,	Chemical Engine,	Jan. 6
Jan. 20.	Winnipeg, Man.,	Arc Lamps,	Jan. 13
Jan. 20.	Charleston, S. C.,	Pump,	Jan. 13
Jan. 20.	Baltimore, Md.,	Lubricating Oil,	Jan. 13
Jan. 20.	Baltimore, Md.,	Pipe, Tools, Paving Materials, Etc.,	Jan. 13
Jan. 20.	Baltimore, Md.,	Garbage Carts,	Jan. 13
Jan. 21.	Fort Dade, Fla.,	Gymnasium Apparatus,	Dec. 30
Jan. 22.	Milwaukee, Wis.,	Valves,	Jan. 20
Jan. 25.	North Vancouver, B. C.,	Road Machinery,	Dec. 23
Jan. 25.	Dayton, Fla.,	Pipe Engines,	Jan. 6
Jan. 25.	Washington, D. C.,	Steel, Wire Rope, Fuses, Etc.	Jan. 13
Jan. 25.	Cincinnati, O.,	Fire Hose,	Jan. 20
Jan. 25.	Leavenworth, Kan.,	Steel Trusses,	Jan. 20
Jan. 26.	Frankfort, Ky.,	Filing Cases,	Dec. 30
Jan. 26.	Washington, D. C.,	Rails, Switches, Etc.,	Jan. 20
Jan. 27.	Pittsburg, Pa.,	Supplies,	Jan. 20
Jan. 29.	Ottawa, Ont.,	Cement,	Jan. 6
Jan. 30.	Mare Island, Cal.,	Elevator,	Jan. 13
Feb. 1.	Leavenworth, Kan.,	Pipe, Etc.,	Jan. 13
Feb. 1.	Jamestown, N. D.,	Water Meters,	Jan. 20
Feb. 1.	Washington, D. C.,	Motors, Blocks, Etc.,	Jan. 20
Feb. 2.	Richland Center, Wis.,	Pump,	Jan. 6
Feb. 2.	Kenosha, Wis.,	Pumping Engine,	Jan. 13
Feb. 5.	Key West, Fla.,	Condenser, Filter, Etc.,	Jan. 6
Feb. 5.	Banff, Alberta,	Sewer Pipe,	Jan. 13
Feb. 8.	Washington, D. C.,	Drills, Valves, Etc.,	Jan. 20
Feb. 15.	Superior Entry, Wis.,	Piles,	Jan. 20
Feb. 17.	Milwaukee, Wis.,	Gas Producer and Gas Engine, Electric Light Plant	Jan. 13
Feb. 22.	Winnipeg, Man.,	Pump, Motor,	Dec. 9

BIDS ASKED

Bridges.

Bids are asked on following work, the notes being arranged alphabetically by states.

Mena, Ark.—Until Feb. 6 by County Judge Wright Pickett, for constructing three bridges for county—one over the Ouachita south of Cherry Hill, one over the Rolling Fork west of Grannis and one over the Cossatot east of Jansson. An appropriation of $9,000 has been made for the bridges.

Kingman, Kan.—Until 2 p. m. Feb. 2 by Bert Walter, County Clerk, for constructing 250-ft. bridge over Chikaskia River 1½ miles west of Spivey, and for constructing 160-ft. bridge over creek in Rochester Township. County will furnish all materials and pile driver for use of contractor.

Topeka, Kan.—Until Feb. 1 by John P. Rodgers, City Engineer, for constructing bridge over Soldiers Creek at Central Ave.

Greenville, Miss.—Until Feb. 1 by W. W. Miller, Clerk County Supervisors, for constructing pile bridge over Black Bayou.

Akron, O.—Until Jan. 25 by M. D. Buchman, County Auditor, for rebuilding bridge over canal at Ira.

Cincinnati, O.—Until noon Feb. 5 by County Commissioners, Fred Dreihs, Clerk, for the following county work: Under Specifications No. 851: For concrete bridge over Muddy Creek at Addyston, Miami Township.

Dayton, O.—Until Jan. 30 by T. J. Kauffman, County Auditor, for constructing sub and superstructure of a bridge over the Miami River at Needmore Road.

Madison, Va.—Until Jan. 22 by H. St. J. Wilson, State Highway Commissioner, Richmond, Va., for constructing steel bridge over Robinson River, about five miles from Madison.

Auburn, Ont.—Until Jan. 25 by D. Patterson, Commissioner Huron County, for constructing steel superstructure for two bridges.

Walkerton, Ont.—Until noon, Jan. 25, by P. A. Malcomson, County Auditor, for constructing 300 ft. steel bridge near Port Elgin.

Buildings.

Bids are asked on following work, the notes being arranged alphabetically by states:

Fort Du Pont, Del.—Until 11 a. m., Feb. 15, by Constructing Q. M., U. S. A., Fort Du Pont, Delaware City, Del., for construction of quarters for two N. C. officers, including plumbing, heating, electric wiring and fixtures.

Washington, D. C.—Until noon, Jan. 25, by District Commissioners, Room 427, District Bldg., for constructing an addition to the Business High School on R St., between 8th and 9th Sts., N. W.

Washington, D. C.—Until 2 p. m., Feb. 16, by Major Cosby, Executive Officer, Room 212, District Bldg., for coping for the municipal building.

Wabash, Ind.—Until Jan. 22, by J. P. Noftzger, County Auditor, for repairs to county court house.

Stanford, Ky.—Until 10 a. m., Feb. 10, by Geo. B. Cooper, County Clerk, for erection and completion of new county court house. Frank P. Milburn & Co., Architects, Washington, D. C.

Baltimore, Md.—Until 11 a. m., Jan. 27, by Edward D. Preston, Inspector of Buildings, for additions and alterations at Pratt St. stables.

Bar Harbor, Me.—Until 3 p. m., Feb. 20, by James Knox Taylor, Supervising Architect, Washington, D. C., for the construction, including plumbing, gas piping, heating apparatus, electric conduits and wiring of the U. S. Post Office at Bar Harbor.

Grand Rapids, Mich.—Until Feb. 15, by Thos. D. Perry, for constructing new high school building for this city.

Greenville, Miss.—Until 3 p. m., Feb. 18, by James Knox Taylor, Supervising Architect, Washington, D. C., for the construction complete of the U. S. Post Office at Greenville.

Fayetteville, N. C.—Until 2 p. m., Jan. 21, by C. J. Cooper, Chairman Building Committee, Southern Life Insurance Co., for the erection and completion of a 5-story office building. W. B. Rose, Architect, Greensboro, N. C.

Salisbury, N. C.—Until 3 p. m., Feb. 17, by James Knox Taylor, Supervising Architect, Washington D. C., for the construction, including plumbing, gas piping, heating apparatus, electric conduits and wiring of the U. S. Post Office at Salisbury.

West Durham, N. C.—Until Feb. 4, by W. A. Erwin, Chairman of Building Committee, for heating and plumbing of group of three buildings at State Hospital for Insane at Morganton, N. C.

Athens, O.—Until noon, Feb. 9, by E. H. Rorick, M. D., Secretary Trustees Athens State Hospital, for materials and labor necessary to construct the domestic hot water supply system at the Athens State Hospital. Frank L. Packard, Architect, Columbus, O.

Cleveland, O.—Until Feb. 1, by Chas. Orr, Director of Schools, for the erection of auditorium at the Buhrer School.

Columbus, O.—Until Feb. 1, by C. J. Palmer, School Commissioner, for the erection of a 12-room school building at the corner of Champion and Hawthorne Sts.

Columbus Barracks, O.—Until 10 a. m., Feb. 8, by Capt. H. J. Hirsch, Constructing Q. M., for furnishing and installing transformer, etc., and making underground electric service connections to new post hospital, new bakery, disinfecting plant, and new hospital corps sergeants' quarters at this post.

Pittsburg, Pa.—Until 10 a. m., Jan. 27, by Edward G. Lang, Director Public Safety, for erection of an engine house and police station at Frankstown Ave. and South Wheeler St. Billquist & Lee, Architects, 341 Sixth Ave., Pittburg, Pa.

Redfield, S. Dak.—Until noon, Feb. 17, by County Auditor, for erection of a county jail building. C. E. Eastman Co., Architects, 401 Observatory Bldg., Des Moines, Ia.

Madisonville, Tenn.—Until noon, Feb. 11, by County Clerk Court, for construction of a new jail, complete.

Fort Myer, Va.—Until 11 a. m., Feb. 9, by Capt. B. B. Hyer, Constructing Q. M., for the construction of a band stable at Fort Myer. Official advertisement will be found elsewhere in this issue.

National Soldiers' Home, Va.—Until 1:30 p. m., Feb. 10, John T. Hume, Treasurer, Southern Branch, N. H. D. V. S., National Soldiers' Home, for material and labor for power house and equipment, tunnels and equipment, commissary storehouse and ice plant, shops with sleeping rooms.

Vancouver Barracks, Wash.—Until 11 a. m., Jan. 29, by Constructing Q. M., for the construction of a quartermaster's storehouse of concrete or brick at Vancouver Barracks, Wash.

Welch, W. Va.—Until noon, Feb. 6, by R. B. Bernheim, Clerk of County Court, for erection of an annex to the county court house. W. E. & E. L. Shufflebarger, Architects, Bluefield, W. Va.

Tomah, Wis.—Until Jan. 26, by Rev. J. G. Glaeser, for the erection of an addition to St. Paul's Church.

Regina, Sask.—Until 5 p. m., Feb. 1, by J. Kelso Hunter, City Clerk, for the general construction of the Regina General Hospital. M. J. Strum, Architect, 84 La Salle St., Chicago, Ill.

Roads and Streets.

Bids are asked on following work, the notes being arranged alphabetically by states:

Columbus, Ind.—Until 10 a. m., Feb. 1, by John M. Davis, County Auditor, for constructing 2 miles of macadam road on Clay and Columbus Township lines.

Decatur, Ind.—Until 10 a. m., Feb. 1, by H. S. Michaud, County Auditor, for constructing macadam road in Hartford Township.

Delphi, Ind.—Until noon, Feb. 1, by M. G. Haun, County Auditor, for constructing three roads.

Fowler, Ind.—Until Feb. 1, by Lemuel Shipman, County Auditor, for about three miles of street improvement in town of Fowler.

Frankfort, Ind.—Until 2 p. m., Feb. 4, by Charles F. Cromwell, County Auditor, for constructing following gravel roads: B. D. Parvis Road, No. 109, in Michigan Township, total length 13,024 ft.; Joseph A. Ogle Road, No. 77, in Forest Township, total length 5,290 ft.; William R. Ashpaugh Road, No. 116, in Johnson Township, total length 13,096 ft.; James T. Peterson Road, No. 114, in Kirklin Township, total length 7,700 ft.; Ingram T. Dell Road, No. 117, in Kirklin Township, total length 12,313 ft.; Homer F. Cheney Road, No. 38, on line between Owen and Warren Townships, total length 5,275 ft.; Oro Kirkpatrick Road, No. 73, on line between Center and Jackson Townships, total length 7,712 ft.

Frankfort, Ind.—Until 2 p. m., Feb. 4, by Chas. F. Cromwell, County Auditor, for constructing following free gravel roads: In Center and Jackson Townships, 7,712 ft.; Michigan Township, 13,024 ft.; Forest Township, 5,290 ft.; Johnson Township, 13,096 ft.; Kirklin Township, 12,313 ft. and 2,700 ft.; Owen and Warren Townships, 5,275 ft.

Kokomo, Ind.—Until 10 a. m., Feb. 3, by A. B. Easterling, County Auditor, for constructing seven free gravel roads.

Paoli, Ind.—Until 2 p. m., Feb. 2, by A. B. Ham, County Auditor, for the construction of 10,737 ft. of road in North East Township.

Spencer, Ind.—Until noon, Feb. 18, by Geo. W. Edwards, County Auditor, for constructing gravel road on line between Clay and Owens Counties.

Valparaiso, Ind.—Until noon, Feb. 2, by Stephen P. Corboy, County Auditor, for constructing following gravel or stone roads: In Jackson Township, 7,642 ft.; Center Township, 13,060 ft.; Center and Porter Townships, 1,124 ft. long.

Vevay, Ind.—Until 1 p. m., Feb. 1, by Scott Culbertson, County Auditor, for constructing a gravel road 15,825 ft. long, in York Township.

Vincennes, Ind.—Until 2 p. m., Feb. 2, by John T. Scott, County Auditor, for constructing 2,000 ft. of gravel road in Vigo Township, and 1,875 ft. of gravel road in Vincennes Township.

Wabash, Ind.—Until Jan. 22, by J. P. Noftzger, County Auditor, for constructing four gravel roads.

Wabash, Ind.—Until 2 p. m., Feb. 1, by Thos. Nugent, County Auditor, for constructing gravel road in Washington Township.

Crawfordsville, Ind.—Until 10 a. m., Feb. 2, by B. B. Engle, County Auditor, for improvement of public roads in Brown and Union Townships.

Greenfield, Ind.—Until 2 p. m., Feb. 1, by Charles H. Troy, County Auditor, for improvement of public roads in Buck Creek, Center and Vernon Townships.

Moorhead, Minn.—Until 8 p. m., Feb. 1, by H. E. Roberts, City Clerk, for constructing brick or creosoted wood block pavement on concrete base. Official advertisement will be found elsewhere in this issue.

Cincinnati, O.—Until noon, Feb. 5, by County Commissioners, Fred Dreihs, Clerk, for the following county work: Under Specifications No. 846, for improvement of Kilby Road, from Valley Junction to Cilley's Corner, Whitewater Township.

Chatham, Va.—Until Jan. 25, by S. S. Hurt, Clerk County Supervisors, for constructing four to six miles of macadam roads. Plans, etc., with J. O. Magruder, City Engineer, Danville, Va., or State Highway Commissioner, Richmond, Va.

Nottoway, Va.—Until Jan. 26, by County Supervisors, County Court House, for constructing six miles of macadamized road. Plans, etc., with P. St. J. Wilson, State Highway Commissioner, Richmond, Va.

Olympia, Wash.—Until 5 p. m., Feb. 1, by J. R. Dever, City Clerk, for constructing about 17,000 sq. yds. of vitrified brick or creosoted wood block pavement, 11,500 sq. yds. of concrete sidewalks and 13,000 lin. ft. of concrete curb. Official advertisement will be found elsewhere in this issue.

Sewers.

Bids are asked on following work, the notes being arranged alphabetically by states:

East St. Louis, Ill.—Until noon, Feb. 17, by Board Local Improvements, W. J. Crocken, City Engineer, for the construction of a system of concrete and pipe sewers and a sewage pumping station as follows: One pumping station building and appurtenances: five drainage and two sewage pumping engines, to be vertical, single acting gas engines, direct connected to horizontal shaft centrifugal pumps; 33,500 lin. ft. of sewers, varying in diameter from 3 to 10½ ft.

Moorhead, Minn.—Until 8 p. m., Feb. 1, by H. E. Roberts, City Clerk, for constructing two lateral sewers.

Brooklyn, N. Y.—Until Jan. 27, by Bird S. Coler, Borough President, for constructing sewer in 46th St., the work including 1,500 ft. of 36-in. brick sewer.

College Hill (P. O., Cincinnati), O.—Until noon, Feb. 8, by Village Clerk, for constructing two 6-in. to 12-in. sanitary sewers. J. A. Stewart, Village Engineer, 1112 Traction Bldg., Cincinnati, O.

Youngstown, O.—Until noon, Jan. 25, by Board Public Service, W. H. McMillin, Clerk, for constructing sewer in Wellendorf Ave., and in Wick Ave. Bond for $200 required with bid.

Park (Sta., Knoxville), Tenn.—Until Jan. 25 (postponement from Jan. 11), by A. Greenwood, 508 Gay St., Knoxville, for constructing $25,000 sewer system for Park.

Parkersburg, W. Va.—Until 8 p. m., Jan. 21, by Frank Good, City Auditor, for constructing sanitary sewer on portions of several streets.

Water Supply.

Bids are asked on following work, the notes being arranged alphabetically by states:

Donovan, Ill.—Until 10 a. m., Jan. 22, by Frank K. Duzenberry, President Board Local Improvements, for 6,565 ft. of water main extension.

Wichita, Kan.—Until 7:30 p. m., Mar. 15, by R. N. Dorr, City Clerk, for material and constructing water works system for the city. Estimated cost is $860,000. Hiram Phillips, Engineer, St. Louis, Mo. Official advertisement will be found elsewhere in this issue.

Sebree, Ky.—Until noon, Feb. 15, by G. W. Cavanah, Town Clerk, for constructing water works, to consist of 60,000 gallon steel tank, distribution line system, two pumps, boiler, etc.

New Ulm, Minn.—Until 5 p. m., Feb. 15, by Ernst Wichehski, City Clerk, for constructing a covered reinforced concrete reservoir of 1,000,000 gallons capacity. H. F. Blomquist, City Engineer.

Falls City, Neb.—Until noon, Jan. 22, by William Schmelzi, City Clerk, for installing water works.

Minot, N. Dak.—Until Feb. 4, by City Auditor, for constructing water works, to include 11 miles of 6-in. to 16-in. mains, steel tower and tank and brick and concrete pumping station.

Hugo, Okla.—Until 8 p. m., Feb. 2, by W. T. Echols, City Clerk, for materials and labor for constructing water works to include: One brick power house, one 3-million gallon concrete reservoir, two 150-hp. tubular boilers, two 2-million gallons pumps each, two 800-cu. ft. air compressors each, 4,185 ft. 14-in. cast iron pipe, 1,790 ft. 12-in. cast iron pipe, 1,610 ft. 10-in. cast iron pipe, 5,510 ft. 8-in. cast iron pipe, 57,485 ft. 6-in. cast iron pipe, 14,365 ft. 4-in. cast iron pipe, 135 fire hydrants, two 14-in. valves, one 12-in. valve, one 10-in. valve, seven 8-in. valves, forty-five 6-in. valves, twenty-two 4-in. valves, 700 water meters, material for 700 house connections. Hiram Phillips, Engineer, St. Louis. Official advertisement elsewhere in this issue.

Avonmore, Pa.—Until 7 p. m., Feb. 1, by Robert H. Wilson, Engineer, Saltsburg, Pa., for materials and labor for building complete water plant for this borough.

Waukesha, Wis.—Until 2 p. m., Jan. 25, by Trustees County Asylum, W. P. Dunlap, Secretary, for drilling deep well and furnishing pump for same.

Miscellaneous.

Bids are asked on following work, the notes being arranged alphabetically by states:

Mobile, Ala.—Pontoons.—Until 11 a. m., Feb. 11, by Maj. H. Jervey, U. S. Engrs., for constructing 61 wooden pontoons.

Boston, Mass.—Cleaning Catch Basins.—Until noon, Jan. 21, by Guy C. Emerson, Superintendent of Streets, for cleaning about 7,000 catch basins.

Boston, Mass.—Wreck Removal.—Until noon, Feb. 6, by Lt.-Col. Edw. Burr, U. S. Engrs., for removal of wrecks of steamers "Germania" and "Reindeer"; canal boats "Geo. D. Cull," "John R. Myers," "North Star," "E. D. Case," "Richmond," "William Parker," "F. J. Bailey," "Governor Roosevelt," "Georgia T." and "Armenia Allore," and hulks of eight other canal boats, names unknown, in the narrows of Lake Champlain, New York and Vermont.

Milwaukee, Wis.—Concrete Caissons, Etc.—Until 2 p. m., Feb. 12, by Maj. W. V. Judson, U. S. Engrs., for building reinforced concrete caissons and pile pier, removing old pier and dredging at Milwaukee Harbor, Wis.

Excavation, Earth and Rock.

Bids are asked on following work, the notes being arranged alphabetically by states:

Atkinson, Ill.—Ditches, Levee.—Until 2 p. m., Feb. 6, by Commissioners of Union Drainage District No. 1, for the construction of 41,300 ft. of open ditches, requiring 163,300 cu. yds. of excavation and 3,400 ft. of levees with an estimated fill of 2,800 cu. yds. H. E. Reeves, Engineer, Atkinson.

Girard, Ill.—Tile Ditch.—Until 11 a. m., Feb. 5, J. F. Stutsman, Clerk, Drainage Commissioners, for material and labor for constructing tile drainage ditch requiring 43,500 ft. of 7-in. to 27-in. tile.

Winchester, Ind.—Ditch.—Until 10.30 a. m., Jan. 25, by Arthur B. Purdier, Commissioner, at office of County Surveyor, for constructing a drainage ditch.

Greenville, O.—Ditch Work.—Until 10 a. m., Jan. 23, by James R. Marker, County Engineer, for constructing two small ditches, estimated to cost $696 and $840.

Velasco, Tex.—Drainage Work.—Until Jan. 30, by Drainage Commissioners, Velasco Drainage District of Brazoria County, Texas, at office of E. P. Hoelle, Velasco, for construction of drainage ditches, levees, revetment work, etc., according to plans and specifications on file in office of commission at Velasco. The ditching will consist of approximately 63,000 cu. yds.; levee will contain 148,900 cu. yds.; revetment work will consist of placing 160 piling and 540 cords of brush mattress.

Materials, Machines, Supplies, Tool, Etc.

Bids are asked on following work, the notes being arranged alphabetically by states:

Washington, D. C.—Drills, Valves, Etc.—Until 10:30 a. m., Feb. 8, by Capt. F. C. Boggs, General Purchasing Officer, Isthmian Canal Commission, for furnishing, under circular 490, wire screening, condenser tubes, cylinder cocks, coupler pockets, manganese steel, anchor winches, anchors, chain, chain swivels, anchor shackles, switchboard and electrical attachments, wire, closet seat rings, hose strainers and nozzles, cross valves, rubber valves, adhesive tape, lead melting furnace and ladles, pipe derrick, pipe cutting machine, post and twist drills, taps, reamers, stocks and dies, pipe cutters, wrenches, vises, hammers, punches, chisels, groovers, cant hooks, tool handles, files, screws, cotters, staples, tacks, snatch blocks, wire rope clips, door plates and pulls, etc.

Washington, D. C.—Motors, Blocks, Etc.—Until 10:30 a. m., Feb. 1, by Capt. F. C. Boggs, General Purchasing Officer, Isthmian Canal Commission, for furnishing, under circular 488, electric motors, ranges, furniture, refrigerators, beds, mattresses, mats, hose, packing, belting, manila rope, cotton waste, cotton duck, valves, brooms, scrubbing brushes, flue cleaners, water closets, chain blocks, tackle blocks, rivets, nuts, rails, wire netting, hammers, wrenches, chisels, picks, coal scoops, door bolts, hose nozzles, hose clamps, machinists' clamps, milk cans, buckets, coal baskets, potato mashers, oil cloth towels, mop heads, sand paper, acids, oils, gasoline, lubricating grease, etc.

Washington, D. C.—Rails, Switches, Etc.—Until 10:30 a. m., Jan. 26, by Capt. F. C. Boggs, General Purchasing Officer, Isthmian Canal Commission, for furnishing, under circular 489, steel rails, angle bars, tie plates, track bolts and spikes, rail braces, frogs, switches, switch stands, ties, etc.

Leavenworth, Kan.—Steel Trusses.—Until 10 a. m., Jan. 25, by R. A. Ladow, Superintendent of Prisons and Prisoners, Washington, D. C., for furnishing and delivering at the U. S. Penitentiary, Leavenworth, Kan., steel trusses.

Jamestown, N. Dak.—Water Meters.—Until 3 p. m., Feb. 1, by G. E. Lyman, City Auditor, for furnishing water meters for the city in lots of 25 and 50.

Cincinnati, O.—Fire Hose.—Until Jan. 2[illegible], by Board Public Safety, for furnishing the Fire Department with 10,000 ft. of 2½-in. cotton, rubber lined fire hose.

Pittsburg, Pa.—Supplies.—Until 10 a. m., Jan. 27, by A. B. Shepherd, Director Public Works, for furnishing supplies to city for period of one year. Among the supplies wanted are: Asphalt repair plant supplies, drafting instruments, cement, lumber, sewer pipe and fittings, street signs, cable, wagons, machine sweepers, etc., etc.

Milwaukee, Wis.—Valves.—Until 10:30 a. m., Jan. 22, by Board Public Works, C. J. Poetsch, Chairman, for furnishing for the use of its water department, two 20-in. and eight 36-in. gate valves and one 36-in. check valve of the Ludlow Valve Manufacturing Co.'s style.

Superior Entry, Wis.—Piles.—Until noon, Feb. 15, by Lt.-Col. Graham D. Fitch, U. S. Engrs., Duluth, Minn., for furnishing and delivering piles at Superior Entry, Wis.

CONTRACTS LET.

The following contracts have been let recently:

Helena, Ark.—Bridge.—Joliet Bridge & Iron Co., Joliet, Ill., at $1,345, for constructing steel bridge over Stamp Creek for county.

Little Rock, Ark.—Paving.—I. P. Shelby, at about $50,000, for paving 50 blocks of streets with vitrified brick.

Colorado Springs, Colo.—Bridge.—Charles G. Sheeley, Denver, Colo., at $3,000, for the construction of the new county bridge near Breed Station, across Monument St. The bridge will be of steel, with cement floor with concrete reinforcement.

Greeley, Colo.—Street Lighting.—The city lighting contract, for five years, has been awarded to the Home Electric Light & Power Co. The rate for all-night every-night 7.5 ampere series arc lights is $[illegible] per year. Free lights are furnished for the City Hall and some other service. The rate for the City Library is 5 cts. per kilowatt hour. As this is all new business, the Home company will have to at once install necessary transformers, distribution system, lamps, etc. Robert McF. Doble, Majestic Bldg., Denver, Colo., is Consulting Engineer.

Holly, Colo.—Water Works.—W. W. Cook Construction Co., Junction City, Kan., for constructing water works for this city.

Des Moines, Ia.—Electric Railway.—Burns & Co., 705 Isabella Bldg., Chicago, Ill., have contract for constructing 20 miles of projected 90-mile line of the Chicago, Ottumwa & Western Electric Ry., which is to connect Des Moines and Ottumwa, Ia.

Hume, Ill.—Bridges.—Clinton Bridge & Iron Works, Clinton, Ia., at $5,[illegible], for erecting seven bridges in Hume Township.

Aledo, Ill.—Bridge.—C. J. Noble, at $1,[illegible]7, for constructing 100-ft. span bridge over Eliza Creek, south of Brown Noble's.

Viola, Ill.—Bridge.—J. Howard Jayne, Monmouth, Ill., at $2,100, for constructing bridge over Edwards River, northeast of Viola. Bridge is to be an [illegible]-ft. span steel structure with concrete floor resting on reinforced concrete substructure.

Bluffton, Ind.—Gravel Roads.—Contracts for constructing gravel roads in Wells County have been let as follows: Wm. Reppert, four roads, $22,274; Ed Engle, two roads, $16,122; L. Hutsell, two roads, $12,7[illegible]; J. N. Kolb, one road, $4,767; C. C. [illegible], one road, $7,600; J. Gordon, one road, $2,[illegible]; G. W. Taber, one road, $[illegible]; T. Turpin, one road, $1,647; M. Alexander, one road, $[illegible].

Brownstown, Ind.—Gravel.—Contracts for gravel roads in Jackson County have been let as follows: James E. Pruett, Houston, Ind., $2,884; Davis & Godfrey, Seymour, Ind., $11,606; Dempsey Manion, Seymour, Ind., $1,404.

Delphi, Ind.—Gravel Roads.—James F. Pierce, Delphi, at $5,419, for constructing gravel road for county; E. E. Bayard, Delphi, at $7,629, for constructing gravel road.

Newcastle, Ind.—Road.—Joseph Alspaugh, Cadiz, Ind., at $6,600, for constructing road in Harrison Township for county.

Covington, Ind.—Gravel Road.—Freeman Noggle, Newport, Ind., at $[illegible], for constructing gravel road in Fountain County.

Rushville, Ind.—Roadwork.—Wm. Avery, Waldron, Ind., at $7,963, for grading and draining highway in Rush County.

Sullivan, Ind.—Road.—J. C. Riggs, Sullivan, Ind., at $1,[illegible], for constructing 1,3[illegible] ft. of road.

Muncie, Ind.—Highway Work.—County Commissioners have awarded following contracts for highway improvements: J. Hayes & Sons, Dunkirk, Ind.; Geo. Sanders and H. J. McClellan, both of Muncie, Ind.

Winfield, Kan.—Sewers.—J. N. Shackelton, at $1,137, for constructing sewer in District No. 6, and at $1,281 for constructing sewer in District No. 7.

Malden, Mass.—Building.—The Converse Rubber Co., recently organized, of which M. M. Converse is President, has placed a rush contract with the Aberthaw Construction Co., of Boston, for the building of their fireproof building in Malden. The new building will be erected next the B. & M. Western Division tracks near Edgeworth Station. The floors and interior columns and stairs will be of reinforced concrete. The exterior columns and roof trusses will be of steel and the walls of brick. The foundations for this building are nearly completed and the work is to be pushed through with all dispatch. The building will be fireproof, modern and up to date.

Evansville, Ind.—Filter Plant.—Norwood Engineering Co., Florence, Mass., at $246,000, for constructing mechanical filter plant for this city.

Grand Rapids, Mich.—Sewage Pumping Station.—Charles E. Williams, at $7,8[illegible], for constructing sewage pumping station at Canal and Coldbrook Sts.

East Grand Forks, Minn.—Pumping Plant.—J. C. Robertson, St. Paul, Minn., for erection of new pumping plant here.

Eveleth, Minn.—Tank.—Pastoret & Lunz, Two Harbors, Minn., for constructing 200,000-gallon water tank for city.

Mankato, Minn.—Bridge.—Contract has been signed with the Hennepin Bridge Co. for the construction of a second bridge over the Minnesota River. Contract price is $27,900, and the work includes the constructing of a high truss steel highway bridge 34[illegible] ft. long, to consist of two spans, each 17[illegible] ft. long, with a 20-ft. roadway.

St. Paul, Minn.—Sewer.—O'Neil & Preston, at $15,00[illegible], for constructing concrete sewer in Fairview and St. Clair Sts.

Laurel, Mont.—Bridge.—Security Bridge Co., Minneapolis, Minn., at $[illegible], for constructing steel bridge over Yellowstone River at Laurel for Yellowstone and Carbon Counties.

Missoula, Mont.—Bridge.—[illegible], at $[illegible], for constructing bridge at [illegible] for county.

Winston, N. C.—Bridge.—Carolina Engineering Co., Burlington, N. C., for constructing steel bridge over Silas Creek at Parker's Mill for the county.

Long Branch, N. J.—Sewer.—[illegible], West Long Branch, for laying sewer to connect artificial pond on the Guggenheim estate with Takanassee Lake, a distance of 1,[illegible]43 ft.

Trenton, N. J.—Sewer.—Anton [illegible], for constructing sewer in Tabor St. and Chestnut Ave.; Thomas McGovern, for constructing sewer in Brunswick Ave.

Niagara Falls, N. Y.—Paving.—Henry P. Burgard Co., Buffalo, N. Y., at $[illegible], for paving 4th St. with sheet asphalt.

Troy, N. Y.—Sewer.—John Flynn, at $1,[illegible]7, for constructing sewer in McManus St.

Le Roy, N. Y.—Church.—Dillon & Matlock.

for erecting St. Joseph's Roman Catholic church on Lake St.

Coshocton, O.—Manufacturing Plant.—Luyster & Lowes, Dayton, O., for constructing buildings for plant for James C. Clow & Sons.

Philo, O.—Power Plant.—F. W. Witherall, Pittsburg, Pa., for building power plant for the Center Valley Light & Power Co. on the site of the Frazier Mill at Philo.

Waynesville, N. C.—Railroad Work.—T. C. McNeely, Hendersonville, N. C., manager of the Appalachian Construction Co., has the contract for constructing the South Atlantic & Transcontinental Ry., surveys for which are now under way.

Lorain, O.—Bridge.—Modern Construction Co., Fremont ,at $1,033, for constructing bridge over Vermilion River at Hillsburg.

Columbus, O.—Viaduct Substructure. — Yawger Co., Indianapolis, Ind., at $87,891, for substructure work on the Mound St. crossing viaduct

Elyria, O.—Building.—H. W. Whitney, for erecting 190x90-ft. finishing building for Elyria Iron & Steel Co.

Hobart, Okla.—Paving. — Quinlan-Warner Co., Syracuse, N. Y., for constructing 14 blocks of asphalt pavement for this city.

Philadelphia, Pa.—Paving Work, Etc.—Filbert Paving & Construction Co., for repairs for ensuing year to city and railway streets paved with asphalt; The McNichol Co., for repairing streets paved with granite block on sand foundation for ensuing year; David McMahon, 7 East Chelton Ave., at $67,400, for maintaining county roads for ensuing year; Daniel S. Pader, for repairing bridges and sewers for ensuing year.

Dallas, Tex.—Bridge.—A. S. Adams, at $4,700, for constructing concrete bridge for city.

Stamford, Tex.—Railroad Work.—P. M. Johnson, St. Elmo, Ill., according ot reports, for the construction of the Stamford & Northwestern Ry. from Stamford to Dickens County. The contract includes grading, bridging and everything with the exception of laying of the steel and ties.

Aberdeen, Wash.—Railroad Work.—Caughren, Winter, Smith & Co., Spokane and Seattle, Wash., are reported to have been awarded the contract for constructing the Grays Harbor branch of the Union Pacific R. R., bids for which were opened Dec. 24. The contract does not include the construction of the bridge over the Chehalis River.

North Yakima, Wash.—Sewer.—Western Concrete Machinery & Manufacturing Co., at $4,750, for extending Beech St. sewer.

Wallula, Wash.—Railroad Work.—Hurst & Woods, Spokane, Wash., have contract for building spur line from the O. R. & N. Ry., near Attalia to a point on the Columbia River, selected for a bridge site. This is said to be the first work in connection with the construction of the North Coast line south of the Columbia River.

La Grande, Ore.—Water System.—American Light & Power Co., Kansas City, Mo., at $146,000, for building Beaver Creek water system for this city.

Antigo, Wis.—Bridge.—Wisconsin Bridge & Iron Co., at $2,337, for constructing one span steel bridge over Wolf River for town of Ainsworth.

Ellis Junction, Wis.—Dam and Power Plant.—Pates & Rogers, 355 Dearborn St., Chicago, Ill., for the construction of a dam and power plant on the Prestigo River at Ellis Junction, Wis. The work is to be done for the Northern Hydro-Electric Power Development Co., and will involve the expenditure of $500,000. The dams are to be constructed of earth and concrete.

PROJECTED WORK.

Bridges.

Items Arranged Alphabetically by States.

Fresno, Cal.—City has rejected bids received some time ago for constructing a concrete bridge over Dry Creek on Belmont Ave. and will call for new bids.

Saticoy, Cal.—E. C. Converse, who recently purchased the Keystone ranch on the east side of Santa Clara River 4 miles north of Saticoy, will, it is said, erect a $30,000 bridge over the river at his ranch.

Essex, Conn.—Shore Line Electric Ry. Co., New Haven, Conn., will, it is said, in the early spring build a bridge over the Meadow land bordering on the Middle Cove Bay from near Macks Landing to the main land on the north side of the meadow.

Atlanta, Ga.—Resolution is before the council calling for an appropriation of $10,000 for building a viaduct from Jackson St. to Oakland Cemetery.

Peck, Idaho.—The Peck Bridge Co. of this city has been incorporated with a capital stock of $15,000.

Council Bluffs, Ia.—Board of Public Works may decide to replace present bridge over Indian Creek and 8th St. with a concrete structure.

Wichita, Kan.—City Engineer will prepare plans at once for steel and concrete bridges across the Little Arkansas River at 11th St.

Carlisle, Ky.—A company is being formed here to construct a steel bridge over Licking River at Parks Ferry. Thomas E. Beeding of Millersburg, Ky., holds a franchise for the bridge.

Holyoke, Mass.—Board of Public Works is to report on the cost of constructing a new bridge over the first level canal at Sergeant St.

St. Joseph, Mo.—Ordinance is before the council appropriating $5,000 for repairing the 6th St. viaduct. The local street railway company will spend a similar amount on the bridge.

Central City, Neb.—Merrick County Commissioners and Polk County Commisisoners are considering building a joint county bridge over the Flatt River about two miles east of Clarks Village, the cost of which will be about $12,000.

Charlotte, N. C.—County Commissioners are considering building a bridge at Rozzelle Ferry.

Carlsbad, N. Mex.—The county has sold $24,500 of bridge building bonds. The proceeds will be used to build bridges at Artesia and Central City and a bridge over Black River near Malaga.

New York, N. Y.—Board of Aldermen have authorized an appropriation of $110,000 for building the new Hunter's Point Ave. bridge over the Dutch Kills Creek. The bridge will be of the lift variety and the approaches will be of concrete and masonry. Plans will be ready in the spring.

Atlantic City, N. J.—The Atlantic City & Suburban Traction Co. of Pleasantville, N. J., is considering the construction of a $250,000 bridge over the Great Egg Harbor.

Cincinnati, O.—Ordinance will go before the council to authorize a bond issue of $283,000 for building the Gilbert Ave. viaduct.

Greenville, O.—Council has passed ordinance providing for the sale of $6,600 of bonds for the construction of a bridge at Broadway.

Columbus, O.—Central Business Men's Association, I. R. Waters, Secretary, and North Side Board of Trade are agitating the building of a million-dollar viaduct at 3d St.

Mansfield, O.—City Engineer is to prepare plans and estimates for the construction of a bridge over the creek at South Mulberry St.

Philadelphia, Pa.—Mayor Rayburn has recommended the construction of new bridges over Hunting Park Ave.

Philadelphia, Pa.—City council has passed ordinance authorizing the construction of a bridge on the line of Roberts Ave. under the Chestnut Hill branch of the Pennsylvania R. R., to cost $40,000. George R. Stearns is Director of Public Works.

York, Pa.—Viewers recommended the rebuilding of the College Ave. bridge. The work is to include a concrete span over the North Central R. R. tracks and the reconstruction of the rest of the bridge.

Maryville, Tenn.—County Commissioners have appropriated $3,000 for the erection of two steel bridges, one over the creek at Wellsville and the other at Griffith Mills near Mint. T. F. Beals, Friendsville, Tenn., is chairman of County Commission.

Athens, Tenn.—County Commissioners are considering the erection of a steel bridge over the Hiawassee River, to cost about $30,000. H H. C. Dodson is Chairman of the County Court.

Lynchburg, Va.—City Engineer Shaner has completed plans and specifications for a concrete viaduct at 5th St.

Railroads.

Items Arranged Alphabetically by States.

Ashdown, Ark.—Surveys were started here Jan. 11 for an extension of the Memphis, Paris & Gulf R. R. to Paris, Texas. An extension eastward from Nashville toward Murfreesboro is already in progress. C. C. Henderson, Nashville, Ark., is Chief Engineer.

Hope, Ark.—Final surveys are reported to have been about completed for the proposed Gulf & Magnolia Northern R. R. The road is to be started from Hope to Magnolia and possibly may be extended to Shreveport. Col. S. Q. Sevier is promoter.

Rogers, Ark.—Arkansas, Oklahoma & Western R. R., W. R. Felker, Pres., Rogers, Ark., is laying out a route for an extension to the southern part of Carroll County.

Los Angeles, Cal.—Los Angeles Harbor R. R. Co. will soon begin construction of a railroad around the west basin of the San Pedro inner Harbor. Condemnation proceedings have already been instituted to acquire the right-of-way. W. J. Arkell is interested.

Douglas, Ga.—The Georgia & Florida Ry., which is now in operation between Hazelhurst, Ga., and Madison, Fla., and will within less than a year complete an extension from Hazelhurst to Augusta, Ga., is to construct its shops at Douglas, Ga. G. B. Hazelhurst, Douglas, Ga., is Chief Engineer.

Sparks, Ga.—Charter of the Georgia & Florida Ry. has been amended so as to permit an extension from Sparks to Adel, a distance of 3 miles.

Atlantic, Ia.—Atlantic Northern & Southern Ry. is making good progress with its new surveys between Audubon and Kimballton. Considerable amount of right-of-way has already been secured. M. N. Esbeck and A. A. Jorgensen, Kimballton, Ia., are interested.

Hutchinson, Kan.—A project is under consideration for the construction of a railroad from this city through Lerado, Boone Springs and Sego in the southern part of Reno County. As proposed, the road will be built from Olcutt, where the Midland Pacific now operates a line, to Iuka. From that place the proposed Kinsley & Edwards County portion of the road will be built. J. W. Cheatum, Lerado (r. f. d. from Langdon, Kan.), is interested.

Garden City, Kan.—Preliminary surveys for the Garden City, Gulf & Northern R. R. have been completed to this place from Scott City and permanent surveys will be started at once, it is said. S. V. Wordall is Engineer in charge.

Conrad, Mont.—According to the announcement of J. M. Ryan, of Great Falls, Mont., Chief Engineer of the Cargill-Withee syndicate, of Lacrosse, Wis., work is to be started the latter part of February on the construction of the steam railroad in Teton County to the large irrigation reservoirs now in the course of construction.

Miles City, Mont.—Surveys on the Miles City-Sheridan Ry route have been practically completed. T. P. Robb, Miles Block, Miles City, is Engineer in charge.

Waynesville, N. C.—Surveys are to be made and right-of-way secured for the proposed line for the Southern Atlantic & Trans-Continental R. R. T. C. McNeely, Hendersonville, N. C., has the contract for constructing the road.

Oneonta, N. Y.—The Otsego-Herkimer R R. Co. has been reorganized with a capital stock of $1,500,000. The incorporators include Daniel W. Coon, Joseph A. Starrett, Herbert T. Jennings, Mt. Vernon, and Edgar P. Holdridge, New York City.

Bartlesville, Okla.—The St. Louis, Bartlesville & Pacific R. R. is stated to have been financed and is planning to have actual construction work begin early in February. The road is to run from Joplin on the east and is to have its offices and shops in Bartlesville. F. M. Overlees is local representative.

Dallas, Texas.—Missouri, Kansas & Texas R. R is reported to be considering double tracking its line between Dallas and Waxahachie.

El Paso, Tex.—Articles of incorporation of the San Diego, El Paso & St. Louis R. R. Co. have been approved. Headquarters of the company will be in El Paso, Tex., and the capital stock is $100,000. The road will run from El Paso to Crow Springs on the New Mexico boundary line, a distance of about 100 miles. The board of directors are A. Courchesne, W. J. Harris, S. T. White, W. C. Davis, J. A. Smith, H. B. Stephens, L. E. Booker, Irvin John, and H. A. Dick.

Seattle, Wash.—Seattle Dock & Terminal Co. has been incorporated with a capital stock of $2,500,000 and proposes to build a belt line railroad and to construct a dock system in the Duwamish Basin. The incorporators are Capt. E. W. Johnson, E. P. Gaffney and J. T. Flynn. It is said that these parties represent a syndicate of New York and New Jersey capitalists engaged in Harbor work in New York, New Orleans, San Diego, Oakland, San Francisco and Portland.

Winnipeg, Man.—The Canadian Pacific Ry., J. E. Schwitzer, Assistant Chief Engineer, Winnipeg, Man., is stated to be planning to spend $[illegible] this year in construction work on its western line.

Manila, P. I.—Secretary of War Wright is considering a plan for improving the railroad facilities in the Philippines by extending the line from Manila a distance of about 20 miles, so as to connect with Baguio. The construction of the line in Southern Luzon from Tayabas to Nueva Caceres, a distance of about 125 miles to connect with the coal fields, is also proposed. Horace L. Higgins is General Manager of the railroad system in Luzon.

Electric Railways.

Items Arranged Alphabetically by States.

Bentonville, Ark. Advices from this place state that all details for the financing of the Missouri-Arkansas Interurban line have been completed. The road will be built, it is said, by the Western Construction Co., represented by George T. Proper and Edward Henry of Minneapolis, Minn. The route finally determined upon is from Joplin, Mo., to Bentonville, thence to Gentry, Tontitown and Springdale, thence back to Bentonville. A branch line will run to Pea Ridge. It is said that the line will not run to Huntsville, Monte Ne or Siloam Springs, for the present at least.

Helena, Ark. City Council has granted a franchise to build and operate a street railway in Helena to J. W. Burks. Mr. Burks is Industrial Commissioner of the Business Men's League and will transfer the charter to an Indianapolis syndicate in which Charles S. Hernly, Newcastle, Ind., is interested. Work is to be started within 60 days and all work completed by Jan. 1, 1911.

Huntington, Ark. Dan W. Patton, Muskogee, Okla., is promoting a project for the construction of an interurban line to connect this place with Midland and Hartford.

Long Beach, Cal.—Pacific Electric Ry. Co., Los Angeles, Cal., will build a line between Long Beach proper and West Long Beach, and operate cars to the western end of the city.

Pasadena, Cal. Pasadena Rapid Transit Co. has been incorporated with a capital stock of $3,880,000 and proposes to build an air line along the route of the old cycle road between Los Angeles and Pasadena.

Los Angeles, Cal.—H. F. Vollmer has asked city council for a franchise for a single or double-track electric railroad from 28th and Hoover Sts., south on Hoover St. to Dalton Ave.

Atlanta, Ga.—Franchise of the Atlanta Griffin & Macon Interurban Ry. has been extended for one year with a provision that the work must be commenced by April 1. W. J. Kincaid, Griffin, Ga., President of the company, is stated to have practically secured necessary capital with which to begin work.

Sand Point, Idaho. City council has granted franchise to a syndicate of 25 business men and firms of the city to construct a street railway. Franchise provides that actual construction work must be commenced by May 1. Preliminary surveys and securing of the right-of-way were to be started at once. The company also proposes to build a line to connect Kootenai and Ponderay with Sandpoint.

Fort Dodge, Ia.—Fort Dodge, Des Moines & Southern R. R. has had preliminary surveys made for a 2-mile spur to the brick yards located near Kalo.

Peoria, Ill.—Promotion work is under way to secure the building of the line between Peoria and Rock Island. It is understood that the road will run the same direction as the Peoria branch of the Rock Island R. R. Mrs. Alice Butler Moore, Davenport, Ia., is promoting the project.

Albany Hill, Ill.—Surveys have been started of the route to be followed by the Tri City and Northern Ry. Co. The first stretch of line to be built will be from this city to Watertown. The People's Construction Co., Davenport, Ia., is promoting the project.

Chicago, Ill. The directors of the Midlothian Country Club, G. R. Thorne President, have decided to electrify the club's railroad, known as the Midlothian & Blue Island R. R. It is estimated that the work will cost about $20,000.

Paris, Ill. Terre Haute, Indianapolis & Eastern Traction Co., Terre Haute, Ind., is reported to be planning to build a line from Ridge Farm to Paris, Ill.

East St. Louis, Ill. East St. Louis & Caseyville Electric Ry. Co. has been granted a franchise for the construction of a street railway through East Lansdown Heights to Caseyville.

Petersburg, Ind.—Chicago Trust Co. is stated to have offered to finance the proposed Jasper Vincennes Electric Ry. provided the people along the right of way would subscribe $150,000 worth of stock. Surveys have been made and considerable right of way purchased. John G. Davis, Vincennes, Ind., is interested.

Iola, Kan.—Kansas City Olathe Ottawa & Iola Ry. is now having surveys made for its proposed road. Considerable amount of right of-way has been secured. The road is to be in a direct line from Iola to Kansas City. The main power plant will be on the Neosho River, near Iola. George A. Wells is Chief Engineer.

Pittsburg, Kan. The Girard Coal Belt Electric Ry., M. G. Vincent, Secretary, Girard, Kan., is to apply to the city council of Pittsburg for a franchise to build an extension of the Coal Belt Interurban from Radley to Pittsburg.

Cherokee, Kan. Joplin & Pittsburg Ry. Co., Pittsburg, Kan., is considering extending its line to this place from Pittsburg.

Portland, Me.—The Portland, Gray & Lewiston Electric Ry. Co., chartered a year or so ago, has completed surveys for its proposed line and will, it is said, have construction work started this spring. The road is projected to connect Portland and Lewiston, Me. John A. Jones, Lewiston, Me., is Chief Engineer.

Flint, Mich.—The Flint & Saginaw Electric Line now under construction, is to be extended to Vassar, Mich.

Missoula, Mont. City has voted to grant a street railway franchise here to J. R. Wharton, Butte, Mont., Manager of the W. A. Clark properties in Montana. According to the terms of the franchise work on the street car system must be commenced within three months.

Reno, Nev.—S. M. Wheeler and Charles Burk, who received a franchise over a year ago for a street railway in this city, are preparing, it is stated, to begin construction on the line.

Portsmouth, N. H.—Proprietor Priest of the Wentworth Hotel has started a movement for the construction of an electric railway from Sagamore Road to Newcastle.

Rochester, N. Y.—The Rochester & Southern Construction Co., which has the contract for constructing the Rochester, Corning & Elmira double-track railroad, is planning to begin work by April 1 on the construction of the section between Rochester and Conesus Lake. It is planned to start the work at two points, Avon and Rush, with gangs working north and south and with a gang working south from Rochester. John Hofman, Rochester, N. Y., is President and Samuel B. Williams, Rochester, N. Y., is Secretary.

New York, N. Y. State Public Service Commission has granted the New York, Westchester & Boston Ry. Co., which is controlled by the New York, New Haven & Hartford R. R. Co., a certificate of public convenience and necessity to construct its line down through the Bronx Borough. The road, which is under construction, is to be a 3-rail system, 109 miles long.

Seneca Falls, N. Y. Geneva, Waterloo, Seneca Falls & Cayuga Lake Traction Co. has been granted franchise to construct a line from the corner of Stephens St. east to the village limits. The franchise was granted in connection with the proposed extension to Auburn. Work on this line is to be started as soon as the weather will permit. W. C. Gray, Seneca Falls, N. Y., is General Manager.

New York City.—The South Shore Traction Co., Times Bldg., New York City, has applied to the State Public Service Commission for a franchise to extend its tracks through Jamaica and Hofman Boulevards and Thompson Ave. to the Queensboro Bridge plaza and thence across the bridge.

Goldsboro, N. C. The Goldsboro Traction Co. has been incorporated with a capital stock of $1[illegible],000 to construct and maintain a street railway. E. T. Oliver, J. H. Trent of Raleigh, N. C., S. I. Blackburn of Richmond, Va., and A. H. Oliver of Goldsboro are interested.

Sapulpa, Okla. The Sapulpa Interurban Railway has been reorganized and money is to be raised to build an extension into the Glenn Oil Fields, a distance of [illegible] miles.

Philadelphia, Pa. Sharon Hill Upper Darby St. Railway Co., a subsidiary concern of the Interstate Railways Co., of [illegible] Mariner & Merchant Bldg., Philadelphia, Pa., has applied to the councils of Aldan and Lansdowne for a franchise through those boroughs. This is the first step towards establishing a direct line from 69th St., Philadelphia, to Wilmington, Del. The right of way has all been obtained through Upper Darby Township and the other sections of the proposed route over which the right [illegible] been granted are within [illegible] Aldan and Lansdowne. The [illegible] to connect with the Chester Traction Co.'s line at Sharon Hill.

Chester, Pa.—Professor [illegible] Smedley of Concordville, Pa., is making good progress in the promotion of the proposed Chester, Concordville & West Chester Electric R[illegible].

Clarion, Pa.—Clarion East Brady [illegible] Electric Ry. Co. proposes to build an electric railway from Clarion to East Brady via Sligo and Rimersburg. The projected length is [illegible] miles and the estimated cost is about $[illegible]. G. E. Arnold and F. M. Arnold of Clarion, Pa., are interested.

Carnegie, Pa.—Right-of-way has been secured and engineers are at work on final surveys for a new traction line from this place to Chester, W. Va., the distance of [illegible] miles. J. M. Reed, Pittsburg, Pa., is President.

Sioux City, S. D. More than half the right-of-way for the projected [illegible] line of the Sioux Falls & Sioux City Electric Ry. has been secured and it is said that the construction work on the road will be started this year. O. H. Smith, Dell Rapids, S. Dak., is President. George W. [illegible], Sioux Falls, S. Dak., is General Manager.

Austin, Tex. Fred F. Beck of Buffalo, N. Y., representing Eastern capitalists, has made a proposition to the Business League of this city for the building of an interurban line between Austin and San Antonio, to cost about $1,[illegible].

Wichita Falls, Tex. J. Edgar S[illegible] has asked the city council for a franchise for an electric street railway. The same to be built within 6 months.

Mt. Pleasant, Tex.—H. W. Peterman of this city, who has a franchise for constructing a street railway from the city to Red Mineral Springs, one mile southeast of town, will start construction work before Feb. 1, it is said.

Sewers.

Items Arranged Alphabetically by States.

San Jose, Cal.—City council has adopted report that the City Engineer prepare plans and specifications for the construction of a brick or concrete sewer to replace the present box outfall sewer. About $[illegible] is available for the construction of the sewer.

Oakland, Cal.—Ordinance has been before the council to construct a sewer in Broadway.

Monrovia, Cal. City Council has adopted plans of F. H. Olmstead, C. E., Los Angeles, Cal., for the proposed new sewer system. Plans call for an expenditure of $1[illegible], for which city will issue bonds.

San Diego, Cal.—City Engineer has been directed to make surveys and plans for the extension of the sewer system farther than that provided in the recent bond issue.

San Jose, Cal.—N. Ellery, State Engineer, Sacramento, Cal., has prepared plans for a water and sewer system for the State Redwood Park.

Mayfield, Cal. Town Trustees will probably call an election to vote on issuing $[illegible] of bonds for the establishment of a sewer system.

Pueblo, Colo. Ordinance has been before the council for the construction of combined storm and sanitary sewer additions in [illegible] sewer sub-districts Numbers [illegible] and [illegible]. The estimated cost is $6,91[illegible].

Putnam, Conn.—Committee [illegible] which Mayor J. J. McCarry is a member has been appointed to consider the installation of a sewer system.

Atlanta, Ga.—Mayor Maddox is advocating a bond issue of $1,000,000 for the proposed extension of the city sewer system.

Paris, Ill.—Board of Public Works has taken steps for constructing a sewer to cost about $1,[illegible]. The work will [illegible] ft. of [illegible] ft. brick or concrete sewer and [illegible] ft. of 36 in. tile.

Moline, Ill.—H. G. Pohlbeck, City Engineer, has been making surveys of [illegible] of East Moline east of the W[illegible] with a view to the laying of [illegible] sewer pipe.

Rock Island, Ill.—Board of Local Improvements has recommended the construction of a proposed 6th ward sewer system which will drain the territory south of [illegible] Ave. It will cost $[illegible].

Belleville, Ill.—Board of Local Improvements has decided to install a [illegible] sanitary and storm sewer to drain the section east of Lebanon Ave. The estimated cost is $[illegible].

Freeport, Ill.—City Engineer Graham estimated cost of constructing concrete sewers in Pine, American, Chestnut and Benton Sts. at $6,300. The contract will be awarded shortly.

Silvis, Ill.—Village Board has passed ordinance for the laying of sewers and water mains to be paid for by special assessment. The improvement will cost about $31,000.

Grundy Center, Ia.—Council has passed ordinance for the building of sewer system the coming summer. The estimated cost is $15,000.

Attleboro, Mass.—Special Town meeting was held Jan. 15 to take action on the report of the committee on sewerage for the installation of the sewer system. The site for filter beds has been secured and bill to provide for the installation of the system will come before the state legislature.

Cameron, Mo.—City is taking steps to secure the installation of the sewer system.

Kansas City, Mo.—Kansas City Terminal Ry. Co., H. L. Harmon, president, is to reconstruct the O. K. Creek sewer from its terminus at 21st and Walnut Sts. through to Turkey Creek. It is estimated that the work will cost $300,000.

Trenton, N. J.—Special Commission of which Abram Swan, Jr., City Engineer, is a member, is considering methods of disposing of the sewage of the city.

Princeton, N. J.—Mayor H. L. Robinson has recommended a further extension of the city sewer system.

Athens, O.—Council is considering construction of a storm sewer in Mill St.

Cincinnati, O.—Council has passed ordinances for the construction of the following sewers: Westward Sewer System to cost $250,000; Waverly Ave., Blaine Road and South Sts., $14,000; Fairmount Ave., $9,816; Baltimore Ave., $11,000; Lidell St., $6,000.

Stillwater, Okla.—M. J. Hoyt has been investigating sewer systems and will report to the city on installing sewer system for this place.

Salem, Ore.—Mayor Rodgers has recommended that the city install a sewer system.

Gaffney, S. C.—City is considering installing sewer system.

Winchester, Va.—City has voted a $50,000 issue of bonds for the installation of a sewer system. W. H. Baker is President of the City Council.

La Crosse, Wis.—City Council has recommended an $85,000 bond issue for the construction of a sewer in Mississippi and other streets in the southern part of the city. The sewer will be egg shaped 56x78 in. in size and will probably be constructed of concrete. George Bradish is City Engineer.

Kenosha, Wis.—City engineer has completed plans for a trunk sewer.

Water Supply.

Items Arranged Alphabetically by States.

Jacksonville, Ala.—Citizens have started a movement to secure better water supply.

San Diego, Cal.—A. G. Crowell, City Engineer, has been working on plans and specifications for the reconstruction of the lower Point Loma reservoir, located a short distance north of the Theosothist Homestead.

Redwood City, Cal.—City proposes to expend about $20,000 in improving its water works.

Pueblo, Colo.—Summit Reservoir & Ditch Co. has been incorporated with a capital stock of $50,000. The incorporators are: J. F. Behell, William Peach and C. C. Knight.

Pueblo, Colo.—G. E. Studebaker, Rockyford, Colo., and J. E. Bennell, Ordway, Colo., have filed plans for a reservoir and ditch system of 20 miles to be located south of Fowler, Colo. The work will cost about $45,000.

Manitou, Colo—Town is to build a reservoir in connection with its present water works.

Palmetto, Fla. City Bond Trustees are preparing to install a new water system with pumping station, pipes and reservoirs.

Tampa, Fla.—Tampa Water Works Co. is to extend its water works system.

Jacksonville, Fla.—City Bond Trustees are considering building an electric pumping station at the foot of Market St. to supply the new 12 in. fire main on Bay St.

Chester, Ill.—D. E. Detrich and Charles Randall have purchased the water works system formerly owned by the late J. Shenck and propose to extend the mains.

Kempton, Ill.—Village trustees contemplate installing an air pressure water works system.

Charlotte, Ia.—Water works system will soon be installed here.

Macomb, Ill.—I. H. Jewell of Chicago, Ill., has reported to the City Council on the cost of putting in a water plant at Crooked Creek.

Silvis, Ill.—Village Board has passed ordinance for the laying of water mains and sewers to be paid for by special assessment. H. G. Paddock, Moline, Ill., is engineer.

Brazil, Ind.—City Engineer Fletcher has been instructed to extend the water main to the new factory that is being put up on the east Ridge St.

Atlantic City, N. J.—City Water Department has asked County Freeholders for permission to lay a new 48 in. wood stave water main on the right of way of the Meadow Boulevard and Jonathana's thoroughfare at Chelsea Heights.

Catskill, N. Y.—Knight & Hopkins, Engineers, Rome, N. Y., have prepared preliminary plans for the Potuck Creek gravity water system for this place.

Carl Junction, Mo.—City has voted a $9,900 bond issue for installing water works.

Niagara Falls, N. Y.—W. D. Robbins, City Engineer, has submitted to the water commission his plan and estimate for the construction of a water works system.

Machias, N. Y.—Machias Water Supply Co. has been incorporated with a capital stock of $20,000. The incorporators are G. N. Cowan, John Hunt, D. J. Davis of Delavan, N. Y.

High Point, N. C. City Council has decided to buy new filter plant.

Hamilton, O.—Property owners on Elm Ave. have asked for the extension of water mains.

Salem, O. City Council is considering extending the water main on Wilson St.

Kiowa, Ckla.—City has voted $38,000 of bonds for water works construction.

Salem, Ore. Mayor Rodgers is urging the installation of a gravity water system.

Kadoka, S. Dak.—City is making arrangements for the installing of a water works system.

Crockett, Tex.—City has voted to issue bonds for constructing water works.

TRADE NOTES.

The general selling agency for the Hadsel mixer, which has heretofore been held by the Keystone Engineering Co., has been transferred to the makers of the machine, the Kingston Manufacturing Co. Mr. P. G. Rimmer, of the Keystone Engineering Co., becomes vice-president and general manager of sales of the Kingston Manufacturing Co., thus bringing the manufacturing and marketing of this mixer into one organization.

The Cyclone Drill Co., of Orrville, O., has rented offices at 419 Fisher Building, Chicago, Ill., and after Feb. 1 will have a Chicago office at that location. In the past few years the Cyclone Drill Co. has secured a large portion of its business from Chicago from mining properties in the North and West. The business from that point having grown to such an extent it was recently decided to open an office there to take care of the trade to a better advantage for both the customers and the company. Mr. J. F. Munn, who has had charge of the Core Drill Department at the factory for several years, will take charge of the Chicago office. Mr. R. R. Sanderson will succeed Mr. Munn at the Orrville office.

The southern office of the Minneapolis Steel & Machinery Co. has heen moved to the New Praetorian Bldg., Dallas, Tex., where Mr. J. P. Greenwood, southern representative, will handle the Texas business of the company.

The Lackawanna Steel Co. has moved its Buffalo, N. Y., office from the Ellicott Sq. Bldg., to the Fidelity Bldg.

Gulich-Henderson & Co., inspecting engineers, formerly specialists and chemists, with general offices in Pittsburg, Pa., have opened a western office and laboratory in the Manhattan Bldg., Chicago. Mr. W. O. Collins, a new member of the firm, will be in charge.

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DREDGE WORK.

Logan, Iowa

Bids will be received by the Auditor of Harrison County at Logan, Iowa, up to 10 a. m. February 10th, for the dredge work on the Boyer River Improvement Ditch, in said county. The ditch is 6.38 miles long and the excavation amounts to 311,000 cubic yards. Construction work to commence on or before April 15, 1909, and be completed by January 1, 1910. For copies of specifications contract and other information apply to

G. W. ATKINS, Auditor,
Logan, Iowa.
Or to SETH DEAN, Cons. Engineer,
Missouri Valley, Iowa.

PROPOSALS FOR A SEWER SYSTEM AND PUMPING PLANT.

East St. Louis, Ill., Jan. 11, 1909.

Proposals will be received by the Board of Local Improvements of the City of East St. Louis, Ill., until 12 o'clock noon February 17, 1909, for the construction of a system of concrete and pipe sewers and a sewage pumping station as follows:

One pumping station building and appurtenances.

Five drainage and two sewage pumping engines to be vertical, single-acting gas engines, direct connected to horizontal shaft centrifugal pumps.

33,500 linear feet of sewers, varying in diameter from 3 to 10½ feet.

The work will be paid for in cash or bonds. Specifications, plans, form of proposal and other information may be obtained from the engineer of said city upon a deposit of $5.

W. J. CROCKEN, City Engineer.

WATER-WORKS.

Wichita, Kan.

Sealed proposals will be received at the office of the City Clerk until 7:30 o'clock p. m., March 15, 1909, for the construction of a water works system for the City of Wichita, Kan. All work and material to be done and supplied according to plans and specifications on file in the office of the City Clerk. All work to be done under the direction and supervision of a special engineer to be employed by the city. The work will be paid for in cash or four and one-half per cent twenty year bonds at the option of the city. Plans and specifications were prepared by Engineer Hiram Phillips of St. Louis, copy of which may be obtained by applying to the City Clerk upon deposit of twenty-five ($25.00) dollars.

The estimated cost of the above improvement is approximately $860,000. All bidders will be required to enclose certified check in the sum of $10,000 as a guarantee of good faith. The Mayor and Council reserve the right to reject any and all bids.

R. N. DORR, City Clerk.

FORT MYER, VA., January 11, 1909. Sealed proposals in triplicate will be received at the office of the Constructing Quartermaster, until 11 o'clock a. m., February 9, 1909, and then opened for the construction of a Band Stable at Fort Myer, Va. Certified check or Surety Company's guarantee for 10 per cent of the amount must accompany each bid. Plans and specifications will be furnished upon application accompanied by a deposit of $5.00 to insure safe return. The government reserves the right to reject any or all bids. Proposals should be indorsed "Proposals for Band Stables," and addressed to CAPTAIN B. B. HYER, Constructing Quartermaster.

WATER MAINS, STEEL TANK, PUMPING STATION, ETC.

Minot, N. D. [illegible]

The City Auditor of the City of Minot, No. Dak., will receive bids on the [illegible] day of February for the construction of a concrete and brick pumping station complete with pumps, filters, etc. Also steel water tower and tank and about eleven (11) miles of mains from [illegible] to [illegible] inches.

L. S. SEVERANCE, City Engineer.

STREET PAVING.

Olympia, Wash.

Bids will be received by the City of Olympia, Wash., until 8 p. m., Feb. [illegible], 1909, for constructing about 17,000 square yards of vitrified brick or creosoted wood block pavement, 11,000 square yards of concrete sidewalks, 17,000 [illegible] of concrete curb. Work to begin May [illegible], 1909.

J. R. DEVER, City Clerk.

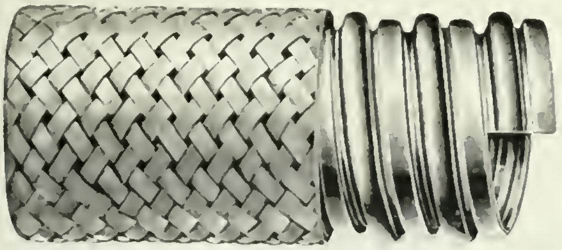
CONCRETE RESERVOIR.

New Ulm, Minn.

Bids will be received by the City Clerk, New Ulm, Minn., up to 8 p. m., Feb. [illegible], for constructing a covered reinforced concrete reservoir of 1,000,000 gallons capacity for the City of New Ulm, Minn.

ERNST WICHERSKI, City Clerk.

KEY WEST, FLORIDA. Sealed proposals in duplicate will be received by the undersigned until 11 a. m. February 5, 1909, and then publicly opened for furnishing a condenser, filter, feed water heater, etc.; also for remodeling pumping and distilling plant at Key West Barracks, Fla. Plans and specifications on request. Proposals should be marked "Proposals for pumping plant" and addressed to CAPTAIN C. H. LANZA, Quartermaster, Key West, Florida.



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STREET PAVING.

Olympia, Washington.

Bids will be received by the City of Olympia, Wash., until 5 p. m., Feb. 1, 1909, for constructing about 6,000 sq. yds. of vitrified brick or creosoted wood block pavement. Work to begin May 1, 1909.

JAMES R. DERER, City Clerk.

U. S. ENGINEER OFFICE, WILMINGTON, N. C., DECEMBER 30, 1908. Sealed proposals for constructing steel draw-span highway bridge with pile and concrete foundations, on Core Creek, near Beaufort, N. C., will be received at this office until 12 o'clock noon, standard time, January 30, 1909, and then publicly opened. Information on application. EARL I. BROWN, Capt. Engrs.

PROPOSALS FOR CONSTRUCTION OF barracks and quarters, and plumbing and heating and electric wiring same. War Department, office of the Constructing Quartermaster, New London, Conn., November 28, 1908. Sealed proposals for constructing one double barrack, one single barrack, two field officers' quarters, one four-set officers' quarters, two lieutenants' quarters, three double non-commissioned officers' quarters, and one double firemen's quarters, at Fort Terry (Plum Island), New York, and two double barracks, two field officers' quarters, four lieutenants' quarters, two double non-commissioned officers' quarters, and two double firemen's quarters, at Fort H. G. Wright (Fisher's Island), New York, and for plumbing, electric wiring and installing heating plants in same will be received here until 10 a. m., Feb. 10, 1909, and then opened. Proposals are desired for brick construction of all buildings and for reinforced concrete construction on bidders' plans of barracks and non-commissioned officers' and firemen's quarters. Information furnished on application. Envelopes containing proposals should be endorsed: "Proposals for Public Buildings," and addressed: "R. M. Schofield, Major, Q. M., Constructing Quartermaster, New London, Conn."

COURT HOUSE.

Omaha, Neb.

Notice is hereby given that the Board of County Commissioners for the County of Douglas and State of Nebraska will receive bids for the construction of a Court House for Douglas County, according to the plans and specifications on file in the office of the County Clerk of said county. Bids will be addressed to D. M. Haverly, County Clerk, enclosed and sealed in properly endorsed envelopes, and filed with him not later than March 1, 1909, at 12 o'clock noon, at which time said bids will be opened.

Copies of the plans and specifications can be obtained from the undersigned or from the Architect, John Latenser, 632 Bee Building, Omaha upon application. A certified check for $50.00 must accompany all applications for plans, as a guarantee that bids will be submitted on the same, the check to be returned when the bids are opened.

All bids must be submitted on blank proposals, which will be furnished on application by the County Clerk, or John Latenser, Architect.

Samples of stone and granite upon which bids are based must accompany each bid.

Each bidder must submit with his proposal a certified check in a sum equal to 3 per cent of such proposal, the same to be drawn in favor of the Board of County Commissioners of Douglas County, Nebraska.

The Board of County Commissioners reserves the right to reject any and all bids.

D. M. HAVERLY,
County Clerk, Omaha, Neb.

OFFICE CONSTRUCTING QUARTERMASTER, FORT LEAVENWORTH, KANSAS, DECEMBER 28, 1908. Sealed proposals, in triplicate, will be received here until 11:00 a. m., Central time, January 27, 1909, and then opened for constructing a storehouse for Officers' Property, etc., at Fort Leavenworth, Kansas. Full information and blank forms of proposal furnished on application to this office. Plans and specifications may be seen at this office, the office of Chief Quartermaster, Department of the Missouri, Omaha and Master Builders Exchange, Kansas City, Mo. United States reserves the right to accept or reject any or all proposals, or any part thereof. Envelopes to be endorsed "Proposals for Public Buildings," and addressed to CAPTAIN WM. D. DAVIS, Quartermaster.

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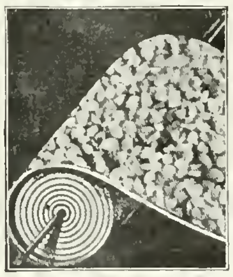

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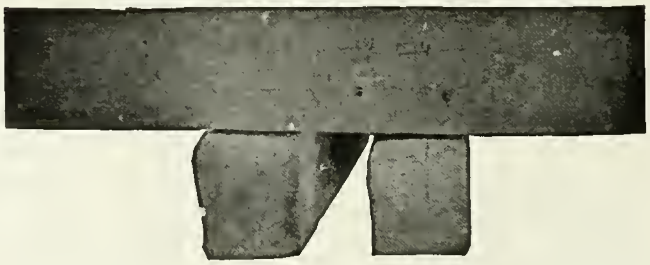

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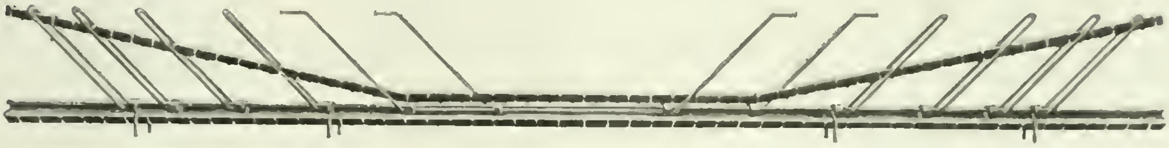

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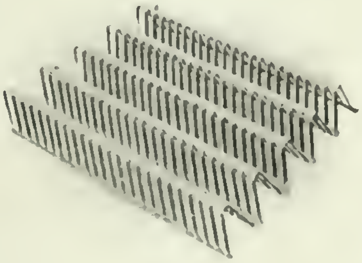

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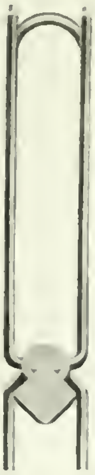

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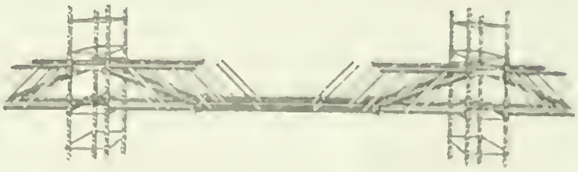

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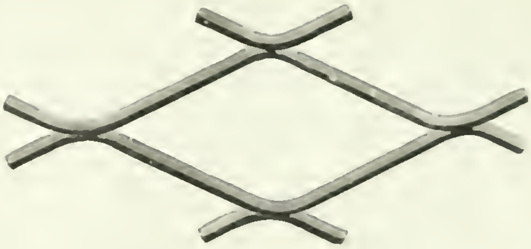

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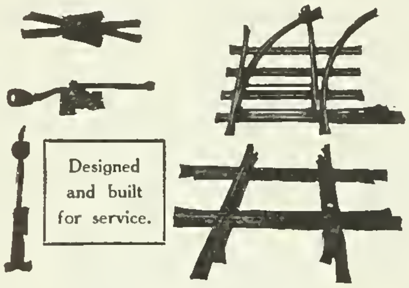
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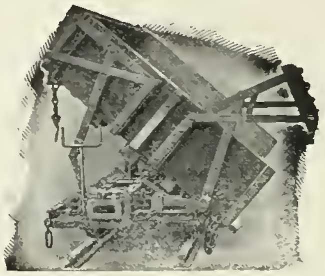

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Milwaukee, Wis., Jan 6, 1909

Sealed proposals will be received at this office until Wednesday, Feb. 17, 1909, at 10 30 o'clock a m., for furnishing and erecting complete in running order ready for use, in buildings and on foundations to be furnished by the city of Milwaukee, all the machinery and appurtenances thereto, necessary to make a complete installation of a gas producer and a gas engine electric lighting plant, said plant to be located on blocks 70 and 95, on the corner of Walker and Davidson streets, in the Fifth ward of the city of Milwaukee, according to plans and specifications (dated Dec. 24, 1908) on file in this office.

Work to be completed within ten months from the date of the award of the contract, failing in which the contractor shall pay to the city of Milwaukee as liquidated damages the sum of $750 per day for each and every day's delay in completing the work.

Bonds to accompany bids required in the penal sum of $45,000, or in lieu thereof the bidder may deposit with the board of public works the sum of $22,500 in money or certified bank check.

In case bonds are submitted with bids, local bondsmen or a surety company authorized to do business in the state of Wisconsin will be required.

All moneys deposited will be returned to unsuccessful bidders on award of contract and to successful bidder when contract is entered into.

Plans and specifications will be furnished to prospective bidders on the receipt of $25 as a guarantee for their safe return.

CHARLES J. POETSCH,
J. P. SHERER,
L. A. JANSEN,
A. J. GRUNDMAN,
Commissioners of Public Works.
AUGUST M. GAWIN, Comptroller.

PAVING.

Moorehead, Minn

Sealed proposals will be received until 8 p. m. Feb. 1, 1909, at the office of the City Clerk, for the construction of pavement according to plans and specifications therefor. Plans and specifications are on file and may be seen at the office of the City Clerk, Moorhead, Minn.

Bids will be submitted to the City Council and opened at a council meeting to be held at the City Hall at 8 p. m., Feb. 1, 1909.

Proposals will be received made out on blank forms furnished by the city through its Engineer, Mr. A. M. Hopeman.

Each bid must be accompanied by a properly certified check upon any reputable bank in the state of Minnesota, in the sum of at least 10 per cent of the amount bid, and made payable unconditionally to the order of Mr. O. C. Beck, City Treasurer, as a guarantee that the successful bidder will enter into a contract with the City of Moorhead in accordance with the plans and specifications and price bid, and furnish a satisfactory bond in a sum equal to 50 per cent of the total amount of the bid, for the faithful performance of the contract.

The right is hereby reserved by the City of Moorhead to reject any or all bids or any part of any bid.

By order of the City Council.

H. E. ROBERTS, City Clerk.

WATER METERS.

Jamestown, No. Dak

Bids wanted for the furnishing of meters for the water system of the city of Jamestown, No. Dak., in lots of 25 and 50.

The city reserves the right to reject any and all bids. All bids must be filed in the office of the undersigned not later than 3 o'clock Monday, February 1, 1909

G. E. LYMAN, City Auditor

COLLEGE BUILDING.

Ames Iowa

Sealed proposals will be received at the office of the Secretary of the Board of Trustees of the Iowa State College, Ames Iowa, until two o'clock p. m., January 28, 1909, for the erection and completion of a two-story Annex for the Engineering Department, plans and specifications for which may be seen at the office of the Secretary at the College and at the office of Proudfoot & Bird, Architects, No. 625 Flynn Building, Des Moines, Iowa.

Bids will be received for the building complete except heating, plumbing and electric work.

Bond, 50 per cent of the contract price, certified check, 3 per cent of the amount of the bid.

The right is reserved to reject any or all bids and to waive defects in any bid if it be deemed to the interest of the College so to do.

By order of the Board of Trustees.

E. W. STANTON, Secretary.

WATER-WORKS.

Hugo, Oklahoma, Jan. 8th, 1909.

Notice is hereby given that the City Council of Hugo, Oklahoma, will, until 8 p. m., February 2d, 1909, receive bids at the City Clerk's office, to furnish materials, tools and labor for the construction of a water-works plant for Hugo, Oklahoma, according to plans and specifications on file with the City Clerk, and also in the office of Hiram Phillips St. Louis, Missouri.

The magnitude of the work to be done is about as follows:

One brick Power House.
One 3-million gallon concrete reservoir.
Two 150 H. P. tubular boilers.
Two 2-million gallons pumps, each.
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5,510 ft. 8" cast iron pipe.
55,485 ft. 6" cast iron pipe.
14,365 ft. 4" cast iron pipe.
135 Fire Hydrants.
Two 14" valves.
One 12" valve.
One 10" valve.
Seven 8" valves.
Forty-five 6" valves.
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700 Water Meters.
Material for 700 House Connections

Bids must be made upon blanks furnished by City Clerk, which will be furnished upon application

A set of blue prints and specifications will be furnished by the Council upon receipt of $3.00, which will be refunded upon receipt of bid and return of plans and specifications.

The Council reserves the right to reject any or all bids.

A deposit of 5% of amount of bid must accompany bid

W. L. GIBBS
Attest Acting Mayor
W. T. ECHOLS Clerk

DRAINAGE DITCHES AND LEVEES.

Atkinson, Ill., Jan. 9, 1909.

Sealed proposals will be received by the Commissioners of the Drainage Union District Number One of the Towns of Atkinson and Alba, in Henry County, Illinois, until Saturday, the 6th day of February, 1909 and until 2 o'clock p. m. of said day, at which time the bids will be publicly opened at the Bass School House, located on the southeast quarter of the southeast quarter of Section 1[illegible], in Atkinson Township, Henry County, Illinois, and within the boundaries of said district. The work for which the bids are desired consists of the construction of [illegible] feet of open ditches with a total estimated excavation of 16[illegible] cubic yards and 3,4[illegible] feet of levees with an estimated fill of 2,800 cubic yards. Specifications for the work may be had upon application to the Engineer, or they may be seen with the plat and profiles at the office of the Engineer or Town Clerk. A copy of the plat and profiles may be procured from the Engineer upon the payment of $1.00. The place of letting is two miles north of Atkinson on the C., R. I. & P. R. R.

H. E. REEVES, Engineer
Atkinson, Ill.
HENRY STELCK, Attorney
Rock Island, Ill.
EDWARD NOWERS, Atkinson, Ill.
ANDREW W. ALLEN, R. F. D. No. [illegible]
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JOHN FRANKENREIDER, Atkinson, Ill.
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POSITIONS WANTED — Two engineers, technical men, experts in highway, sewer and concrete construction, wish partner with plant. Address Box 85, Engineering-Contracting, 355 Dearborn St., Chicago.

WANTED—POSITION—Civil engineer who has been superintendent on sewer, concrete, highway and water works construction wishes position with engineer or contractor. Address Box 83, Engineering-Contracting, 355 Dearborn St., Chicago. 2-1t

WANTED—SITUATION—Young man, technical graduate from first-class university, desires honorable position with engineer or construction company. Middle or northwest preferred. Address Box 74, care Engineering-Contracting, 355 Dearborn St., Chicago.

WANTED—POSITION as chief clerk or assistant superintendent. Young man 28 years old. Familiar with railway construction, mining and quarrying. Experience in the states, Canada and Newfoundland. Can give best of references. Address A. L. Miller, Safe Harbor, Penna. 2-3t

WANTED—POSITION as chemist or chemical engineer by graduate of leading technical school. Has had several years of practical experience and can fill responsible position. Best of references. Address Box "P. C.," care Engineering-Contracting, 721 Park Row Bldg., New York City. 17-tf

WANTED — POSITION with contractor. Have had six years' experience as engineer, chiefly on railway work. Prefer concrete work; location not important. If there is a vacancy on your staff let me hear from you. Address Box 77, care of Engineering-Contracting, 355 Dearborn St., Chicago. 27-2t

WANTED—POSITION — Young man, 28, graduate in civil engineering from first-class college, desires position with engineering company. Four years' experience as instructor in civil engineering in two first-class colleges. Some practical experience at odd times. Address Box 86, care of Engineering-Contracting, 355 Dearborn St., Chicago. 2-2t

WANTED—POSITION—Young man, for several years associated with large corporation as chief engineer's assistant, is open for engagement. Experienced in maintainance and construction of manufacturing plants. Location no object. Address Box 82, Engineering-Contracting, 355 Dearborn St., Chicago. 1-2t

WANTED—POSITION—Young man, 23, wants position with contracting company with idea of learning work. Do not care what salary is to start. Graduate civil engineer, with three years' experience in paving, sewer, water works and concrete construction. Any location. Address Box 76, care of Engineering-Contracting, 355 Dearborn St., Chicago.

WANTED—POSITION—Superintendent with ten years' practical experience in charge of construction, railroads, power plants, barge canal, foundations, pile and sheet driving, heavy concrete construction, rock and quarry work, up-to-date stone crushing, concrete mixing, steam shovel and derrick plants, open for engagement Jan. 1, 1909. First-class references from present employers. New York or Pennsylvania preferred. Age 32. Address Box 73, care of Engineering-Contracting, 355 Dearborn St., Chicago.

WANTED—POSITION on construction or other work with either railroad, manufacturing or construction company by graduate civil engineer. Four years experience on various construction work, two years as assistant engineer in direct charge of heavy railroad construction. Can furnish best of recommendations and A-No.-1 references. Graduate of one of best engineering colleges in this country. Now employed, but desire to better my position. No promoting schemes or drafting jobs will be considered. Address Box 75, care of Engineering-Contracting, 355 Dearborn St., Chicago, Ill.

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WANTED—POSITION—Mechanical and civil engineer, four years' experience as contractor's superintendent, highway, railroad and building construction, wants position. Address Box 84, Engineering-Contracting, 355 Dearborn St., Chicago.

WANTED — POSITION as superintendent with contracting or engineering firm by man who has had broad experience in all sorts of foundation work and general building construction. Address "C. P.," 721 Park Row Bldg., New York. 27-3t

WANTED—SITUATION—Young man, technical graduate from first-class university, desires honorable position with engineer or construction company. Middle or northwest preferred. Address Box 74, care Engineering-Contracting, 355 Dearborn St., Chicago. 3-4t

WANTED—POSITION—Engineer (married) wishes change. At present employed on large contract. Good reason given. South or Southwest preferred. At present assistant engineer. Address Box 78, care Engineering-Contracting, 355 Dearborn St., Chicago, Ill. 1-tf

WANTED—POSITION — Ornamental iron draftsman, broad experience high grade work, stairs, elevator enclosures, bank interiors, desires change. Permanent growing position, preferably executive. Address Box 79, care of Engineering-Contracting, 355 Dearborn St., Chicago, Ill. 1-3t

WANTED POSITION—Graduate civil engineer, six years' experience on railway location and construction, drainage and municipal work; desires position as instrument man, draftsman or assistant engineer. Write for references. Address Box 72, Engineering-Contracting, 355 Dearborn St., Chicago.

WANTED—POSITION — General foreman wants position. Sewer, paving, plain and reinforced concrete buildings, culverts, sewers, floors, curb, gutter, and granitoid walks. No. 1 reference. Can measure, lay out and figure same. Can use transit and level. Familiar with cost of above. Address Box 88, care of Engineering-Contracting, 355 Dearborn St., Chicago, Ill. 3-3t

WANTED—Civil engineer and surveyor, office and business in suburbs of Chicago, wishes to associate with Chicago engineer who requires an assistant; technical graduate; experienced in municipal work, street paving, sewer construction, land surveying, railway engineering and construction. Address Box 71, care of Engineering-Contracting, 355 Dearborn St., Chicago. 23-4teow

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Entered as second-class matter, April 17, 1907, at the Post Office at Chicago, Illinois, under act of March 3d, 1879.

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A Proposed Form of Contract in Which the Contractor Agrees to Do the Work at Prices Fixed by a Third Party, Called the "Estimator."

The American Institute of Architects has a standing committee on Uniform Contracts and Specifications, to which has been submitted a novel form of contract. Mr. Geo. C. Nimmons, architect, has outlined the following plan. He would have an independent, skilled estimator prepare a detailed estimate of the cost of every building. This estimator might do all the estimating for all the architects in a city of moderate size, and would be paid a fee for his work. Having prepared a careful estimate in detail of the cost of a proposed building, the contract would be awarded to some reliable firm of builders at the price estimated by this independent estimator.

The estimator would keep detailed costs of the building during construction. Should the actual cost exceed the estimated cost, the excess cost would be shared equally by the contractor and the owner. Should the actual cost be less than the estimated cost, the saving would be equally shared by the contractor and the owner.

It is claimed that such a contract would harmonize the interests of the owner and the contractor, and that "the contractor and his craftsmen could really work with the architect in a spirit of true sympathetic co-operation, for the real good of the building. If this were possible, it would tend to create a spirit of true art in our work, which has not been present in it to any great degree for centuries."

Such a form of contract possesses obvious merits when applied to architectural work, but it possesses equally obvious defects. The "independent estimator" would have to select either *average* unit costs or *minimum* unit costs in preparing his estimate. If average unit costs were selected, and if the contract were awarded to a contractor of more than average ability as a manager of men, the contractor would have a nice profit to "share" with the owner. If the estimator were to select minimum unit costs, every contractor would lose money unless he were capable of doing the very best that had ever been done.

Architects unquestionably have a great deal of trouble with contractors over specifications, and it is natural that they should seek to change existing conditions. The fundamental difficulty, however, is the ignorance of architects as to actual unit costs.

Architects seldom estimate in any other unit than the cubic foot of space or the square foot of floor area, and they rarely call for bids except in lump sum. They never prepare detailed bidding sheets as engineers do, hence they have no definite knowledge of the cost of the various items, and know almost nothing as to the [illegible] effect of any wording of [illegible] specifications. It is small wonder that under such conditions of ignorance there should be trouble with contractors [illegible] when the architect [illegible] of drawing [illegible] tion for what he wants and [illegible] reasonable prices from reliable competing firms. A little ambiguity in a specification here and a little more ambiguity there, will lead a conservative firm of contractors to bid "unreasonably high," while the same ambiguity will lead a reckless firm to bid very low, taking a gambler's chance. Architects, seeing such wide variations in bids, attribute the variations to ignorance on the part of contractors. It is ignorance—ignorance of what the architect is likely to require under the specifications.

Until architects adopt the practice of engineers in preparing itemized quantity sheets upon which to secure unit prices, and until they make a study of actual costs, they are likely to make little advance in the art of economic construction of handsome buildings, for under any form of contract that is incomplete or ambiguous there must be either antagonism between architect and contractor, or an excessive price paid for harmony.

The Builder of the Manchester Ship Canal Condemns the Building of the Panama Canal by Day Labor.

An unprejudiced English observer of what is being done at Panama is Sir Robert Perks, Bart., M. P., a member of the firm of Charles Walker & Co., who built the Manchester Ship Canal. Speaking of the present policy of building the Panama Canal by day labor, instead of by contract, he has said:

"According to my experience, government work by government departments never is well done, never is quickly done, and never is cheaply done. The average foreman and workman says to himself: 'Oh, [illegible] it is for the government.' He knows that the sooner he gets the work done the sooner he is out of a job. Hence the Uganda Railway, built by the British government, using [illegible], cost twice as much as [illegible] by the [illegible] contractors, and I could put [illegible] of the same kind."

There can be [illegible] of this [illegible] among men who have seen much of government day labor [illegible] compared its cost with that of contract work. Whether the government be American or English or Japanese, the [illegible] the inefficiency of day labor is [illegible].

* * *

Dredge No. [illegible] of the Atlantic Division of the Isthmian Canal [illegible] work [illegible] excavated [illegible] cu. yds., an average of [illegible]. The dredge is of the [illegible] type.

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Concrete and Reinforced Concrete Section

Note:—This section is devoted to methods and cost of constructing concrete and reinforced concrete structures. It will cover the selection, testing and proportioning of concrete materials; laboratory tests of concrete; concrete mixing, transportation and placing; fabrication and placing of reinforcement, and form construction and erection. It will also contain articles on new and interesting developments in the design of reinforced concrete.

Method of Underpinning a Building Wall With a 55-Ft. Span Reinforced Concrete Girder.

A reinforced concrete girder having a clear span of 55 ft., a depth of 14½ ft. and a width of 3½ ft. has recently been constructed to support the west wall of the Evansville, Ind., water-works pump house which was undermined by an accident to the intake pipes. The sketch Fig. 1 shows the sub-surface conditions and other details original ground surface was at 22 ft. above datum and consisted of a bed of silt which reached to —2 ft. below datum. Below this came a layer of fine sand reaching to —22 ft. below datum. Underlying the sand was a bed of firm gravel on which the pump pit was founded. Overlying the silt stratum is a rolled fill immediately surrounding the pump house; this fill formed the material on which the spread foundations of the building rest.

During the construction of the building, which had very heavy masonry walls, settlement occurred, due, it is thought, to the compacting of the silt stratum and the layers of vegetable matter which it contained. No noticeable further settlement has taken place since construction, so that it is thought that the compressible material has been thoroughly compacted. At the time of measurement in July, 1908, the building was 11½ ins. below original level at the southwest corner, which is the right-hand corner in the sketch Fig. 1. At the diagonally opposite corner the settlement had been 3½ ins.; the tilt of the building from northeast to southwest was practically uniform. This settlement ceased after construction and caused no serious trouble. Meanwhile, however, after construction, trouble was had with the intake pipes.

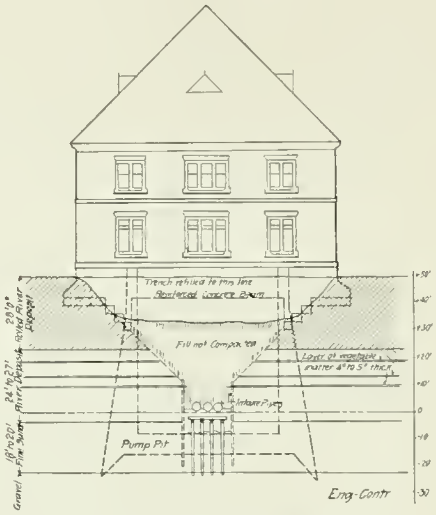

Fig. 1—Sketch Showing Subsurface Conditions and Repair Work.

The three intake pipes reaching about 200 ft. from the pump well to the river intake broke down. In the original construction these pipes had been hung by chain slings from transverse timbers resting on piles on the two sides of the trench; they had no other support but the silt. As the result of this opening up of the pipes they began to take in sand and gradually a cavity was formed in the sand stratum and the back fill settled into it, leaving a hole on the surface. The pipes choked up and repairs were necessary. It was attempted first to sink caissons from the surface to close the break. The first caisson was too small and was abandoned. A second larger caisson was partly sunk and also abandoned because by that time the closing of the intakes threatened a water famine and more immediate resorts were necessary; these consisted of laying a temporary intake which met the situation so well that no haste was made in going on with the permanent intake repairs. Two different contractors were given the work and both failed, then the water-works company undertook it by day labor.

The old piles on each side of the trench were pulled and close sheeting driven as shown by the dotted lines in Fig. 1. Excavation was carried down between this

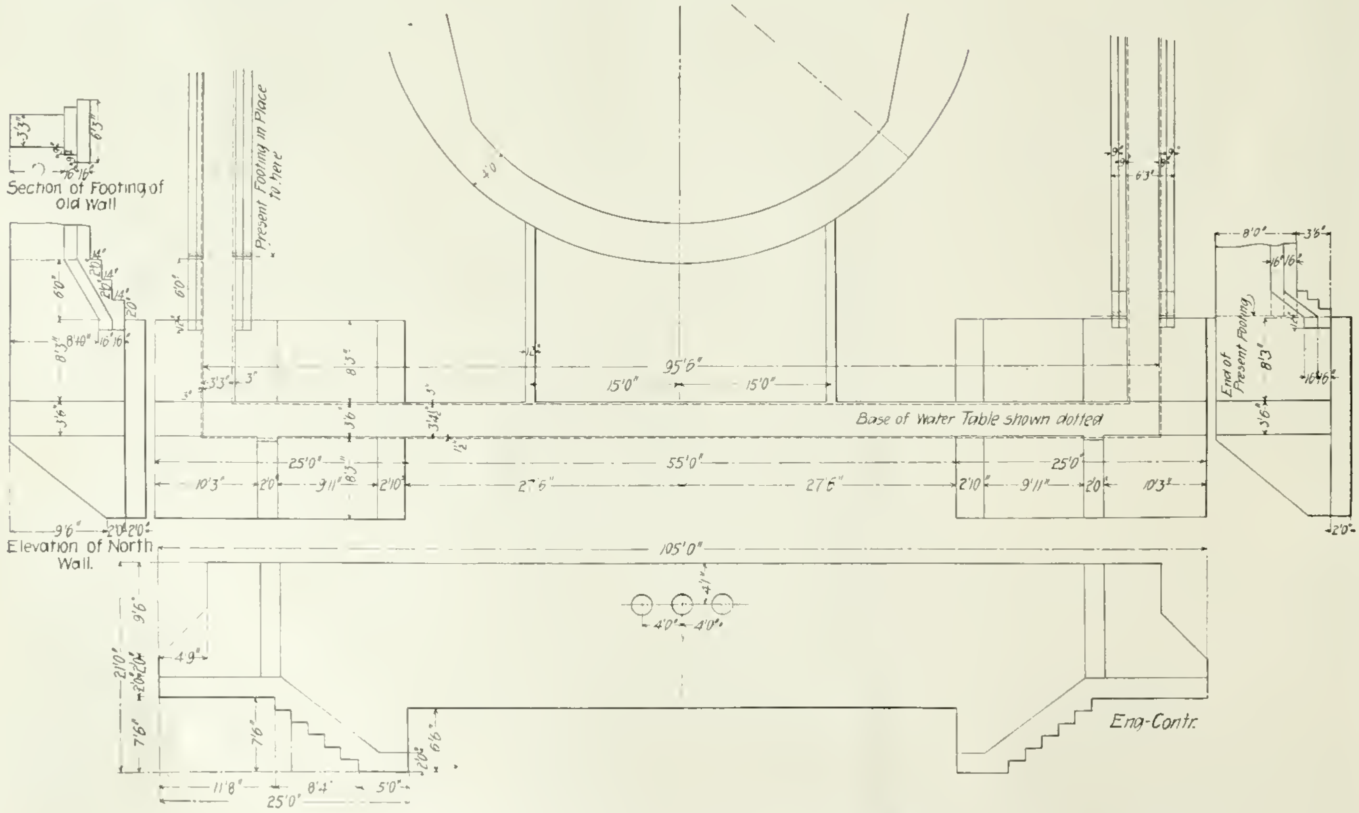

Fig. 2—General Plan of Girder and Footings.

sheeting to well into the sand, and the pile and grillings foundation was constructed as shown by Fig. 1. The completed pipes were finally embedded in concrete and covered over as indicated by Fig 1. The next task was to rebuild the west wall of the pump house which had been taken down when the surface material first began to settle as described above. The designing of the wall repairs was turned over to Alvord & Burdick, Hydraulic and Sanitary Engineers, of Chicago, who decided to underpin the wall with a long span reinforced concrete girder and to replace the original wall with one of much lighter construction. It is the girder underpinning that is of particular interest.

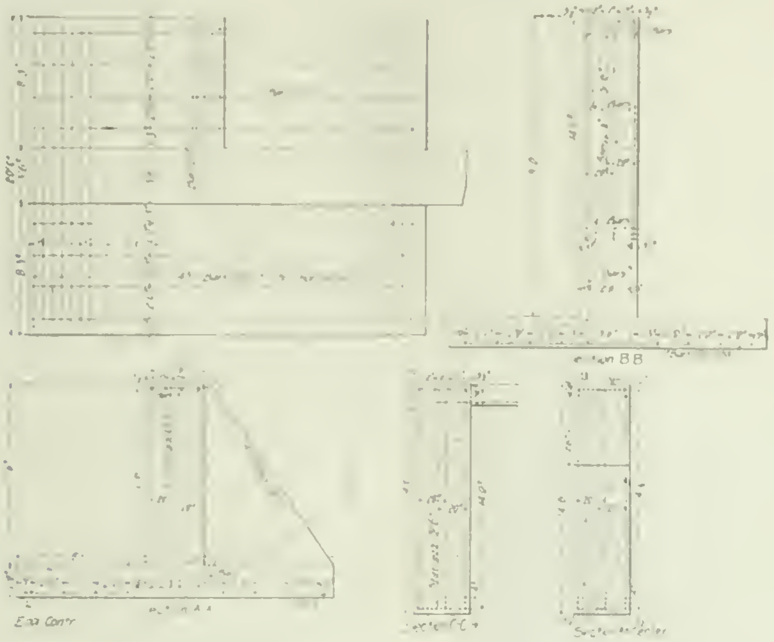

Fig. 3—Details of Footing and Girder.

In planning this girder underpinning, which is shown in diagram by Fig. 1, it was decided to found it on the rolled fill, using a spread footing at each end, as this fill appeared solid and since the only other resort would be to sink foundations to the gravel stratum, which would entail great expense and also by undermining the fine sand endanger the pump well foundations. The girder was, therefore, designed, as shown by Figs. 2, 3 and 4. With the footings as designed the load brought on the foundation bed was about 1,600 lbs. per sq. ft. The drawings of Fig. 2 show the general plans of the girder and foundations. It will be noted that the girder was braced to the pump pit, also that the footing is of stepped construction.

Details of the footing are shown by Figs 3 and 4. It will be observed that it is heavily reinforced. Fig. 4 shows the reinforcement of the girder in connection with the sections, in Fig. 3. The girder and the wall supported by it aggregates a load of 7 tons per running foot. A span of 80 ft. and this load were assumed in calculating the girder. The safe stresses in the steel was assumed at 16,000 lbs. per sq in. and the compression in the concrete at 650 lbs. per. sq. in. Steel was used to assist the concrete in compression, as is shown by Fig 4 The reinforcement consisted of M/B cold twisted bars furnished by the Wm. B. Hough Co., of Chicago, Ill. It was specified to be of mild steel, billet stock, having before twisting an ultimate strength of 60,000 lbs., an elastic limit of 30,000 lbs., and an elongation of 25 per cent in 8 ins., with a reduction of area of 45 per cent. After twisting the elastic limit was to be not less than 55,000 lbs. per sq. in. and the bars were required to bend without cracking 180° on a radius equal to the diameter of the bar The quality of the concrete was specified with equal care A 1-2-4 mixture was used. The sand was required to be Torpedo sand less than ¼ in in size and the broken stone to range from 2 ins. to ⅛ in. in size Batch mixing by machine and very careful work were required.

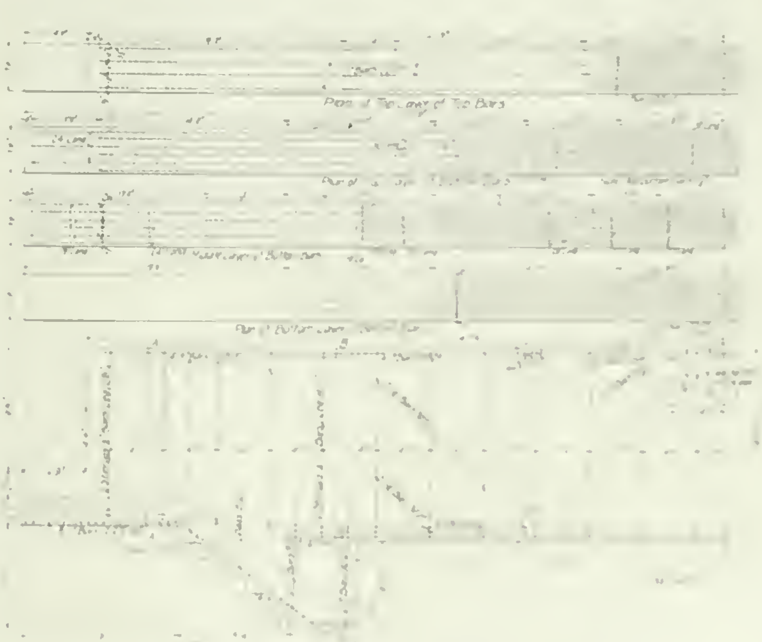

Fig. 4—Details of Girder and Reinforcement.

Fig 5 shows the girder under construction; the form work, runways, etc, are clearly indicated by the view The forms were required to be finished whenever the concrete surfaces were to be visible. The footings were constructed first with the haunch or depressed portions of the girders The forms for the girder proper (Fig 5) were then erected and the reinforcement placed. The concreting was done in 1-ft. layers the full length of the girder and was made as nearly as possible a continuous operation. Particular care was employed in placing both steel and concrete to secure the very best workmanship. A sloppy concrete was used. The forms were kept in place 30 days and no load put upon the girder within that time.

The girder was built by day labor under the direction of Mr. C. C. Culp. E. C. & E. R. Shankland, of Chicago, Ill, were consulted regarding the design of the girder by the engineers, Alvord & Burdick, of Chicago, to whom we are indebted for the information from which this article has been prepared.

The total receipts in 1908 from timber sales from the National Forests of the United States was $819,027. The amount of timber cut from all the National Forests was 392,792,000 ft., B. M., as against 194,872,000 ft in the previous year. This figure for 1908 does not include the 131,482,000 ft given away to settlers, schools and churches under "free use" permits.

Value and Cost of Steam Curing of Concrete Blocks.*

BY F. S. PHIPPS.†

A block cured with steam vapor is harder and stronger at the expiration of 24 to 30 hours than a block cured by the old way of sprinkling or spraying at the end of 7 to 10 days. The method of manufacture is as follows: The blocks are made in ordinary machine and transferred into the ovens, where there is no sun or current of air to cause them to dry before they start to set. As soon as an oven is filled it is cooled and within 1 to 2 hours the steam is turned on and it immediately condenses upon the block the same as dew on grass, and in less time than it is possible to spray a block, it is filled with moisture. In this way a block can be given so much moisture that it will become mushy and mash before the cement sets. This fully refutes the argument that steam curing dries the blocks before they have the proper amount of water.

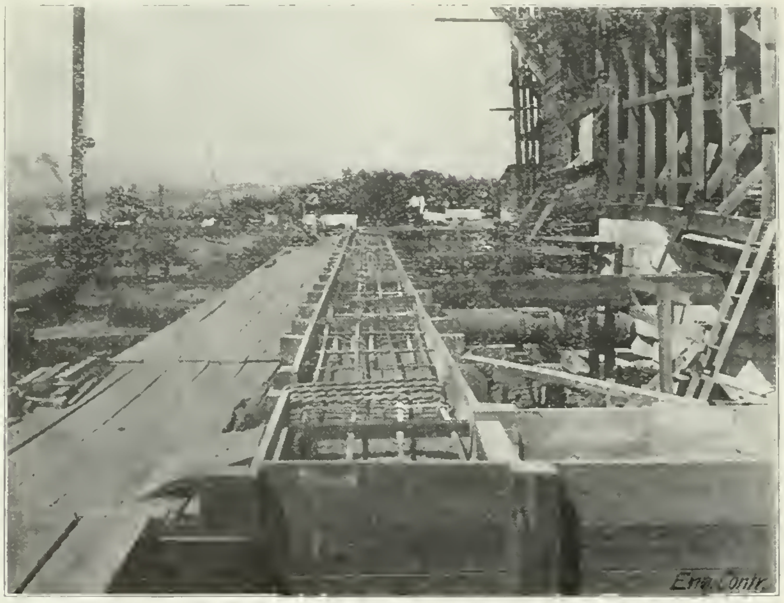

Fig. 5—View Showing 55x14½x3½ ft. Reinforced Concrete Girder Under Construction.

If a steam-cured block produced in 24 hours is equally as good or better than a block made in 7 days under the sprinkling process, is this point not worth considering in installing a steam-curing plant? Further, blocks can be delivered upon a contract within 28 hours after starting the plant, doing away with the one great objection the buyer has against concrete blocks—that of being compelled to wait several days for them after placing the order. A denser block can be produced as the steam does not wash any of the cement from the block, as is the case with the sprinkling process. Also the color of the blocks is more uniform, regardless of the cement used. I have made blocks using dark, as well as light cement, and find that they are almost the same color; the steam gives them a lighter color than it has been possible to obtain before. With steam curing, blocks can be made all winter, which gives the same opportunity to build with blocks as with brick. Again, in the case of rush orders, delivery can be made in 36 hours, or just as quick as stone can be obtained. It has been my experience that under the system of steam curing, a better block is produced, both in color and strength, and a block that is much more salable than the old water-cured block.

We are using Kaw River sand, which is sharp and clean and costs, delivered, including shrinkage and waste, $1.10 per cu. yd. The price of cement at the present time is $1.25 per barrel. Our proportions range from 1 to 3 and 1 to 5 and our cost for 1 to 5 proportions is 3 cts. per sq. ft. and for 1 to 3 is 5 cts. per sq. ft., face. With one man to take care of the boiler, ovens, engine, and the mixing of the materials, at $2 per day, and two men to run the machines at $1.75 per day, we turn out 560 sq. ft. of block. Allowing 50 cts. per day for coal and $1 for office help, our blocks cost us for labor very close to 1¼ cts. per sq. ft.; with the 3 cts. added for material in the 1 to 5 block, the cost will be 4¼ cts. per sq. ft. and for the 1 to 3 block 6¼ cts. per sq. ft. These figures do not allow for insurance, wear and tear on machinery or the manager's salary. If three men were used on the machines, instead of two, the cost would be no greater for mixing or for curing than it is for two men. As nearly as we have been able to ascertain, 1,000 to 2,000 lbs. of coal will cure three ovens of blocks, each oven containing from 140 to 160 blocks. Our men on machines are able to turn out per day 140 blocks, 32 ins. long by 9 ins. high, giving 2 sq. ft. to the block. The blocks we make for building purposes are 4-in. L-shaped blocks, ranging from 4 to 33 ins. To build a wall from 8 to 12 ins. thick, we use two 4-in. blocks; the cost must be figured on a 1 to 3 proportion for outside wall at a cost of 6¼ cts. per sq. ft. and 1 to 5 proportion for inside wall at a cost of 4¼ cts. per foot, making a total cost of a 12-in. wall 10½ cts. per sq. ft. The hollow block that we make is somewhat cheaper as it is only 9 ins. high and 8 ins. wide. It costs about one-third less for material and about the same for labor.

The cost of plant will depend on the size and equipment desired. We have a 25-HP. boiler, which cost, with all piping and fittings, $225, and it makes steam for 6 to 9 ovens. The ovens cost about $50 each. Almost any old boiler will answer, and the oven can be made of sheet iron, although I would not recommend this class of oven.

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*Abstract of a paper presented to the National Association of Cement Users, Cleveland Convention, Jan. 13 to 16, 1909.

†Manager, Central Stone Co., St. Joseph, Mo.

Advantages and Cost of Reinforced Concrete for Small Culverts.*

One interesting, though perhaps not very important, use of reinforced concrete as applied to railway structures is found in small culverts.

On a piece of rather heavy railroad construction recently undertaken, it was decided that no smaller opening than that furnished by a 24-in. cast iron pipe would be considered advisable even for the comparatively small drainage areas cut off from the general drainage course by a railway embankment. Bids were asked on the basis of using cast-iron pipe for all such structures. Owing to the roughness of the country over which the large and heavy pipes would have to be drawn by team from the nearest railroad station, the contractors showed a ready willingness to substitute concrete culverts for the cast-iron upon which they had bid. It was therefore decided to figure on the use of semi-circular concrete culverts of about the same capacity, with the following results:

A 3-ft. semi-circular reinforced concrete culvert of 4.78 sq. ft. of cross section suitable for all fills up to 50 ft. could be built for $4.85 per lin. ft. ($1 for steel bars in place and $3.85 for concrete).

The cast-iron pipe specified for this same fill would cost $7.31 per lin. ft. and where a concrete bed would be required for it in places at an additional cost of $1.70 per ft., the total cost would be $9 per lin. ft.

If, however, the lightest weight of 24-in. cast-iron pipe were acceptable to the railway company, and no concrete bed or cradle required beneath the pipe, still the pipe culvert would cost $5.69 per lin. ft. as against $4.85 for the reinforced concrete culvert.

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*Extract from a paper by B. H. Davis presented to the National Association of Cement Users, Jan. 13-16, 1909.

During 1908 a total of 820 miles of good roads was constructed in New York state.

Methods and Cost of Constructing a Concrete Sewer in Freezing Weather.

The work consisted of a sewer 1,360 ft long and 30 ins. in diameter, with a 4-in shell constructed during November and December, 1908, with the thermometer ranging 15 degrees above zero to above freezing point. The necessity of using frost preventives added about 2½ cts. per lin. ft. to the cost of the work. The following is a description of the sewer and its construction. The location of the work was at Fond du Lac, Wis.

About four years ago the city dug an open drain along a highway upon the outskirts of the city for carrying stormwater into DeNeveu creek. On account of the ditch washing into the road it was decided to place a pipe in this trench and backfill over it. Accordingly the city engineer drew plans and specifications for receiving bids on three kinds of construction: (1) monolithic concrete with 4-in. walls; (2) double strength vitrified pipe, and (3) Jackson concrete pipe. The lowest figures among six competitive bidders were per lineal foot for Jackson pipe $2.50, for vitrified pipe $2.10, and for monolithic concrete $1.245. The contract was awarded to Burett & Dooley for the monolithic concrete sewer. The contract was awarded on Nov. 10, and a few days later work was begun. Owing to the lateness of the season the city officials were concerned at first about the hazard from freezing weather, but they were convinced of its unimportance by the means planned by the contractors to prevent frost damages. These means proved wholly successful, as is described later.

The sewer, as before indicated, was 1,360 ft. long and 30 ins. inside diameter, with 4-in. walls; it contained, therefore, about 1/9 cu. yd of concrete per lineal foot. In addition there were 17 cu. yds. of concrete in the two abutments or portals at the ends of the sewer.

The itemized total cost of the sewer was as follows:

Items—	Total.	Per Lin. Ft
Labor	$ 635.50	46.72 cts.
Tools	24.59	1.81 "
Sandy gravel	208.10	15.32 "
Lumber	14.04	1.03 "
Water	11.35	0.83 "
Frost preventives	34.38	2.53 "
Cement	370.19	27.22 "
Steel forms	204.35	15.02 "
Engineering	132.00	9.71 "
Totals	$1,634.80	$1.20

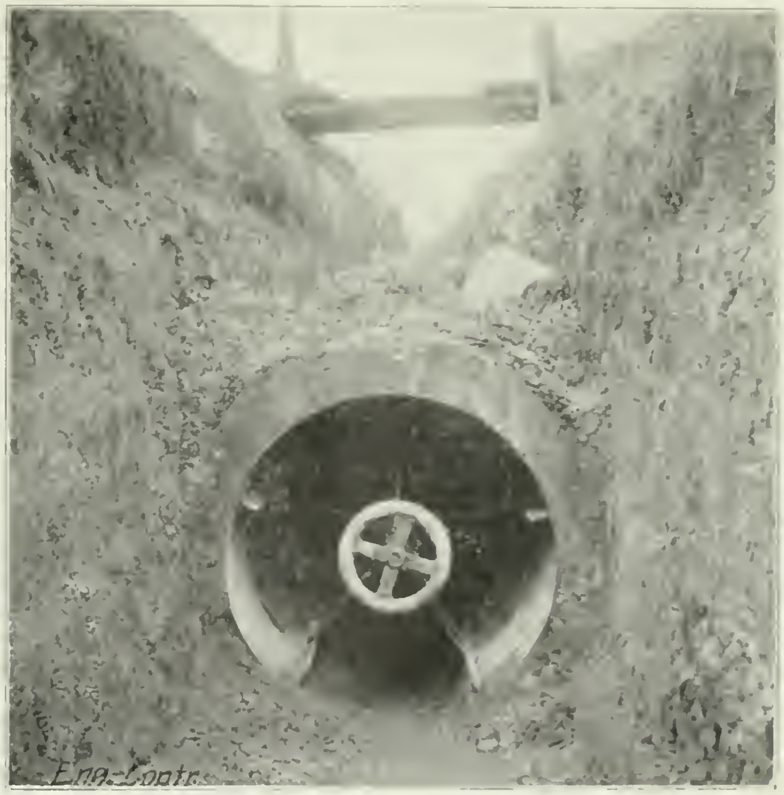
In this statement the labor item is for unskilled laborers at $2 per day, working from 3 to 11 men a day for 29 days and 2 foremen at $3 each for 31 days. The cost items for tools, lumber and frost preventives are the differences between their purchase prices and what they fetched when afterwards sold. The sandy gravel was purchased delivered from three different pits at $1.50 per load of about 1.75 cu. yds., with some at 10 cts. extra per load, a cost, therefore, about 90 cts. per cu. yd. The gravel was mixed to obtain the greatest density of aggregates, and 5 parts of gravel were mixed with 1 part cement to make the concrete. The cement cost $1.70 per barrel delivered in sacks, less the rebate on sacks returned. Water cost for hauling only, 35 cts. per load. The lumber was used for abutment forms and for establishing grades. The frost preventives consisted of horse stable manure, marsh hay, and a thin layer of flax straw sewed between two sheets of rosin paper and also fuel for heating the concrete materials. The steel forms were rented and the cost includes drayage to and from the job and a small sum for oil to grease them. The charge for engineering covers the entire expense to the city and township for plans, specifications, advertising, inspection of sewer during construction, etc.

Separating the abutments containing 17 cu. yds. of concrete the cost was as follows:

Items—	Total	Per Cu Yd
Labor	$25.50	$ 1.50
Tools	00.59	0.035
Gravel	15.00	0.882
Cement	32.01	1.883
Lumber	04.04	0.237
Water	00.60	0.035
Frost preventives	1.88	0.110
Centers	0.75	0.045
Engineering, etc	5.00	0.295
Totals	$85.47	$5.021

Some of these items are actual amounts and others are close approximations. The costs for the sewer proper arrived at in the same manner were as follows:

Item	Total	Per Lin Ft	Per Cu Yd
Labor on concrete	$254.00	$0.187	$1.683
Labor excavation	357.00	0.263	2.367
Tools	23.00	0.017	0.153
Gravel	193.10	0.142	1.278
Lumber	10.00	0.007	0.066
Water	10.70	0.008	0.072
Frost preventives	32.50	0.024	0.216
Cement	338.18	0.249	2.241
Center molds	203.60	0.149	1.341
Engineering	127.00	0.093	0.837
Totals	$1,549.43	$1.139	$10.251



View Showing Adjustable Steel Centers Used in Constructing the Sewer.

In the above table the amount for the concrete labor includes the labor cost for heating the materials, mixing, and depositing the same in position complete, also for the small expense of operating the steel forms. The rest of the labor expense was for excavating the trench an average depth of 3 ft. and for back filling. This was done, as noted previously, in an old ditch, the bottom of which was red clay soil, requiring but a slight expense for trench bracing. No water ran in the trench except on a couple of days it rained when the water ran out soon through the molds into the sewer, as shown by the accompanying illustration made direct from a photograph of the work.

Flax straw, bound in paper already put up, was tried as a cover to the green concrete pipe, to keep frost away while the cement was setting, but the vapor from the concrete softened the paper cover so that it could not be handled and the article had to be discarded. The horse stable bedding of straw proved to be efficient for keeping frost out of the green concrete, it generating a certain amount of heat and allowed the moisture to pass through it from the heated concrete. Due to the chemical changes going on in this cover, too strong an article should not be laid next to fresh concrete, as in some places on the pipe it was observed that the cement did not set good for a depth of 1/16 to ⅛ in. A thin layer of marsh hay was placed between the manure and the concrete on the balance of the work and the condition did not appear again.

In the steel forms lighted oil heaters were placed at short intervals to keep up summer conditions while the cement made its initial set.

The style of the centers used was the full circle form so that the crown and invert of the pipe were built in one operation. The materials were mixed on a flat No. 12 gage steel sheet, size 60x156 ins. Concrete was put in the bottom of the trench first, which was dug somewhat rounding, and graded 4 ins. thick. Strips of No. 26 gage sheet steel 12 ins. wide by 8 ft. long, previously rolled to the arc of 30-in. circle, was next laid, one piece lengthwise on this bed, then one 5-ft. section of steel forms was placed upon the strip, or track. The form was expanded to size by turning the hand wheel, shown in the cut to the right, the correct diameter being obtained by fitting a wire hoop gage around the near end of the center and expanding the center against the gage. Another batch of concrete now ready was positioned around the form, an operator at the front end of the form having a steel blade, 5 ins. wide by 10 ins. long, affixed to a long handle, tamped the concrete firmly to place under the two bottom quarters of the form so that the possibility of voids or pockets forming in the bottom of the concrete pipe to be refinished later, was eliminated, the concrete being positioned on top of the form nearly out to the end. Another form being set, the process described was repeated until all the forms used on the work was concreted.

The object of using a light steel track, or slide, under the forms was so that the molds could be drawn out easily the next morning one at a time, and to prevent scraping out with them partially set concrete from the bottom of the sewer, the steel track being laid with lapped ends so that the forms could slide over the joints and not disturb the track. The track was, of course, taken each morning from the sewer after the centers were withdrawn and used repeatedly.

Collapsing of the centers was accomplished by merely giving the hand wheel a few turns to the left, when the mold was pulled out of the sewer with a rope and taken ahead in the trench for resetting when needed. No bracing of the forms was required to keep them in alignment. The top of the concrete pipe was shaped with a wood hand float, the concrete for this purpose not being made wet enough to make it sloppy.

The adjustable steel centers as used on this job was handled upon the desirable unit plan; however, all the forms may be set before placing concrete about them, or in any other way that may appeal to a contractor as most advantageous. Two Y-connections were made to this sewer by placing the small ends of clay pipes against the steel forms as the concrete was being positioned. The next morning when the steel forms had been removed the first connection had some concrete to be broken out of the end and refinished while the one made later was found perfect. Gas engine oil thinned with kerosene and applied with a brush to the surface of the molds prevented the adhesion of concrete to the forms. The temperature varied during construction when concrete was made from 15° above zero to above the freezing point. The thermometer one morning registered 12° below zero, but by 10 o'clock it showed 15° above when concreting was started. One foreman with a crew of six men often put in 70 ft. of sewer in less than 5 hours' time.

The style of mold used on this job is patented by J. E. Dooley, and is manufactured by the Adjustable Steel Centering Co. of Fond du Lac, Wis. We are indebted to the contractors, Burett & Dooley, for the information from which this article has been prepared.

Cubic Foot Costs of Reinforced Concrete Buildings.—The following costs are for buildings actually erected and they are given by Mr. Emile G. Perrot, M. Am. Soc. C. E.:

	Cents per Cu. Ft.
Warehouses and manufactories..	8 to 1
Stores and loft buildings........	11 to 17
Miscellaneous, such as schools and hospitals	15 to 20

These costs include the building complete, omitting power, heat, light, elevators and decorations or furnishings.

Extending Concrete Piles Above Ground—In constructing simplex concrete pile foundations on ground which had afterward to be filled in, the piles were extended above ground by the following method: The Simplex pile was constructed in place in the usual manner by driving a steel shell and depositing the concrete inside as the shell was withdrawn. When the concrete filling reached the surface and while still wet, a cylindrical form was centered over the pile and filled in to the required height of the extension above ground. The engineers marked the grade level of the top of the pile on each form as it was placed. The forms were left in place about 24 hours and then removed and used over again. The work was done by the Cranford Paving Co., of Pittsburg.

Coming Conventions of Interest to Cement Users.

The following associations of cement users will hold conventions during the next few weeks for the discussion of subjects relating to the manufacture and use of cement products and for the exhibition of machinery and tools for concrete work:

Iowa Association of Cement Users.—Convention at Des Moines, Ia., on Feb. 2, 3 and 4, 1909. Convention hall at the Savery Hotel, Locust and Fourth streets; exhibition hall at the Curzon Building on Court avenue, between Second and Third streets. Sessions will be held on the afternoon of Feb. 2, morning and afternoon of Feb. 3, and morning of Feb. 4. Exhibits should be addressed to Exhibition Hall, Curzon Building, Des Moines, Ia. Blank applications for exhibition space may be secured from Secretary Ira A. Williams, Ames, Ia., to whom remittance and requests for information should be addressed.

Nebraska Cement Users Association.—Convention at Lincoln, Neb., on Feb. 10, 11 and 12, 1909. Convention hall at the Lindell Hotel, 13th and M streets; exhibition hall, Auditorium, 13th and M streets. The exhibition will be restricted to articles not for sale; no patented article will be allowed among the exhibits; no fee will be charged for exhibition space. Secretary I. E. Walenpaugh, Lindell Hotel, Lincoln, Neb., should be addressed for exhibition blanks and information.

Cement Products Exhibition Co.—The exhibition will be held at the Coliseum, Chicago, Ill., Feb. 18 to 24, 1909. No technical meetings are held, the occasion being solely an exhibition of cement machinery, tools and products. This is perhaps the largest exhibition of the kind held in the United States and the visitor is certain of seeing examples of practically all classes of cement machinery and cement products. Secretary L. L. Fest, Cement Products Exhibition Co., New Southern Hotel, Chicago, Ill.

Northwestern Cement Products Association.—Convention at Minneapolis, Minn., March 2 and 3, 1909. Convention and exhibition halls at the Armory. Secretary, J. C. Van Doorn, Minneapolis, Minn.

The six track shifting machines in the Central Division of the Isthmian Canal moved a total of 510,568 ft., or 96.7 miles of track during December. In the Tabernilla District track shifter No. 5 moved 100,703 ft., or 19.1 miles. At San Pablo and Caimito shifter No. 6 moved 62,546 ft., or 11.8 miles. At Gorgona and Matachin No. 7 moved 139,697 ft., or 26.5 miles. At Santa Cruz, No. 1 moved 57,392 ft., or 10.9 miles. At Miraflores No. 8 moved 64,880 ft., or 12.3 miles, and at La Boca track shifter No. 2 moved 85,350 ft., or 16.2 miles.

Earth and Rock Section

Note: This Section is devoted to methods and costs of excavating earth and rock and building embankments. It will cover the grading of roads and railroads, diking and canal work, dredging, building reservoirs and earth dams, sewer and water pipe trenching, quarrying, etc.

The Cost of Excavating a Small Cellar with Drag Scrapers.

Data on the cost of cellar excavation is scarce, especially for small buildings and shallow excavation. These small jobs of excavation are seldom undertaken with the proper force or equipment, with the result that the work generally costs more than it should.

The following costs are in connection with cellar excavated in stiff clay. The depth of the excavation was 4½ ft., the building being 30½x33 ft., with an angle 5x16 ft., cut out of one corner. The number of cubic yards in it was 155. The costs given include the expense of trimming up the sides. The clay was plowed and then excavated with drag scrapers, the excavated material being dumped on the sides of the bank. At first two teams were used, and an extra man for loading the scrapers. When most of the material was excavated only one scraper was used, and one of the three men was put to work dressing down the sides with a pick. A runway excavated for the scrapers to enter the pit contained 3 cu. yds., making in all 158 cu. yds.

The cost was as follows:

85 hrs. scrapers at 50 cts	$42.50
72 hrs. laborers at 15 cts	10.80
Total	$53.30

The cost per cu. yd. was:

Scrapers	$0.269
Labor	0.068
Total	$0.337

This cost could have been reduced by working three scrapers in the gang instead of two, and then one, and by employing an extra man to keep down the sides. With only two scrapers the pace of the teams would be a slow one. This is shown by the fact that only 1.86 cu. yds. of material was moved by a scraper per hour, when at least 3 cu. yds. should have been excavated. Then with only two scrapers, there were times when only one scraper was at work when plowing was being done. With three teams the pace set would have been much faster. It would also have been possible to have worked one team overtime and thus have had most of the plowing done when it would not have interfered with the regular work of the scrapers.

Assuming that three scrapers would have excavated at the same rate as was actually done, there would still have been a saving as one man would have done the loading for three instead of two scrapers. Three scrapers would have moved 56 cu. yds. in 10 hours, at a cost for teams of $15 and $1.50 for the extra man, a total of $16.50 or a cost per cubic yard of 29½ cts. With two scrapers 37 cu. yds. were moved in 10 hrs., the cost being $11.50, or a cost per cubic yard of 31 cts., thus showing a saving with the three scrapers of 1½ cts per cu. yd. The increased pace set by the extra team would have effected a greater saving than this. The cost per cubic yard should have been from 3 to 5 cts. less than it actually was.

We are indebted to the "Canadian Engineer" for the information upon which this article is based.

In connection with the work of construction of structures on the Interstate Canal, North Platte Project, the cost data kept show some interesting facts in connection with the sand and gravel used, states the Reclamation Record. The structures consist of culverts, inverted siphons, sluiceways and lateral headworks. The quantity of gravel required per structure varied from 791 to 19 cu. yds. with an average of about 190 cu. yds. The quantity of sand required varied from 396 to 10 cu. yds. per structure and averaged about 102 cu. yds. Laborers were paid at the rate of $0.30 and teams and drivers at the rate of $0.45 per hour.

The following table gives a summary of the unit costs per cubic yard:

Distribution of cost.	Gravel 4,136 cu. yds	Sand 2,255.5 cu yds.
Preparatory	$0.135	$0.076
Screening	0.479	0.362
Hauling	0.770	0.821
Total	1.384	1.262
Hauling per mile	0.513	0.418

According to Consul-General Richard Guenther, of Frankfort, a new dirigible air ship will soon be constructed in Germany. It is the invention of Professor Schuette, of the Technical High School of Danzig, Prussia. The balloon will be 310 ft. in length and about 50 ft in diameter. The skeleton frame will not be composed of aluminum, but of double diagonal wooden ribs. The car or basket is to be about 120 ft. long and 12½ ft. wide. The screw propeller will be driven by two gas motors of 150 h.p. each. The average speed is estimated at 50 English miles per hour. As the carrying capacity is considerably enhanced by substituting wood for aluminum, the new air ship will be able to take, besides the usual outfit and crew, from 1,000 to 1,500 lbs. of freight

Methods and Costs of Stripping Iron Ore With a Steam Shovel.

Mining by stripping is becoming more common in this country every year. This is due to the advent of steam shovels in the excavation field. Iron ore has been mined by stripping since the beginning of the industry in this country, but naturally the ore beds had to be both thick and rich to make it a paying proposition, and there are today in the various iron mining regions many workings lying idle because it was too expensive to work them with forks and shovels. Steam shovels today are sometimes found stripping very thin veins of ore, with a deep overburden. This is the case at the mines of the Furnaceville Iron Co., near Rochester, N. Y. The ore of this company's comes to the surface about 1¾ miles south of Lake Ontario.

In the present workings the overburden is about 20 ft. in thickness, 10 ft of which is limestone, more or less shaly, the upper part being soil and glacial material. The ore varies from 20 to 22 in. in thickness. The ore deposits of this vicinity were discovered about the year 1800, but it was 25 years or more before they were worked with any regularity, while it has only been within the last 30 years that the output has been large. At first the ore was only worked where the overburden was the lightest. Picks and shovels and wheelbarrows were used to remove the dirt. About 20 years ago two Boston steam shovels manufactured by the John Souther Co., of Boston, Mass., were put to work at the ore stripping. These shovels have been operated during this period more or less continuously and they are still used for special work.

These two shovels worked one behind the other stripping a width of 60 ft., each shovel taking 30 ft. The great improvement in this work has been in the manner of handling the excavated material, and in the use of one modern steam shovel in doing the stripping.

For this purpose there is now being used a Vulcan Giant steam shovel of 2½ cu. yd. dipper capacity, manufactured by the Vulcan Steam Shovel Co., of Toledo, Ohio. This shovel is capable of making a cut 56 ft. wide but at present it takes out a cut only 40 ft. wide and 20 ft deep. This shovel loads the material into self dumping skips of 5 cu yd. capacity that are operated on an inclined conveyor, built by the Dobbie Foundry & Machine Co., of Niagara Falls, N. Y. This conveyor has made possible a great increase in the amount of overburden handled. The incline is 120 ft in length and makes a waste bank about 60 ft. in height. It is possible to haul the skip to the top of the incline, dump and return in 30 seconds, but naturally this speed is not maintained in the ordinary work. While one skip is being dumped, the other is in place for loading. The conveyor has housed at the base of the incline a 50 h.p. double drum hoisting engine, each drum working independently of the other. There is also a steam winch for moving the machine forward. The machine is mounted on rails laid down for the purpose, and is moved by means of a rope, operated with a "dead man" from the winch. The conveyor is operated by four men, a hoisting engineer, a fireman, a winchman and a topman.

The overburden is blasted before being excavated by the steam shovel. For this purpose two churn drills, mounted on wheels, and with their own boilers, manufactured by the Austin Manufacturing Co. of Cleveland, Ohio, are used to drill the holes. The holes, 6 ins. in diameter, are drilled on 15 ft. centers and extend a few inches into the ore. Each drill requires one man and burns about 400 lbs. of coal in 10 hours. The cost of operating a drill per day of 10 hours is:

Labor	$2.50
Coal	.70
Supplies (estimated)	.30
Plant (estimated)	1.00
Total	$5.50

Each drill puts down an average of 4 holes per day or a total of 80 lin. ft., thus costing about 7 cts. per lin. ft. for drilling, which is quite cheap. For each cubic yard of material excavated 0.09 lin. ft. of hole was drilled making a cost for drilling of 0.6 cts. per cu. yd.

The holes are shot with 10 per cent dynamite, using on an average 65 lbs. of explosives to the hole, worth 13 cts. per lb., thus using 0.3 lb. per cu. yd., costing 4 cts.

The steam shovel working under favorable conditions, with machinery for promptly handling the excavated material handles a large yardage during the 10-hour working day. Work is done throughout the entire year, only stopping for the most severe weather. The shovel excavates from 1,200 to 1,700 cu. yds. of overburden per day or an average of about 1,500 cu. yds.

The cost of operating the steam shovel per day is as follows:

Foreman	$3.50
Shovel runner	2.50
Cranesman	2.00
Fireman	1.75
3 tons of coal at $3.50	10.50
Oil and supplies	.50
8 laborers at $1.30	10.40
Plant (estimated)	6.00
Total	$37.15

This gives a cost for excavating and loading with the shovel of 2.5 cts. per cu. yd.

The cost of transporting and dumping with the conveyor per day is:

Engineer	$2.50
Winchman	2.00
Topman	2.00
Fireman	1.75
2 tons coal at $3.50	7.00
Oil and supplies	.50
Plant (estimated)	6.00
Total	$21.75

This gives a cost of 1.5 cts. per cubic yard.

The total cost per cubic yard for stripping is as follows:

Drilling	$0.006
Explosives	0.040
Loading	0.25
Conveying and dumping	0.015
Total	$0.086

No allowance has been made for general expense. Although the wages paid are somewhat smaller than those paid for excavation work by contractors, yet the total cost for this class of work is very low.

There are some interesting facts in connection with the breaking up and excavating of the ore. The stripping disposes of the waste material with the exception of about 8 ins. of limestone capping over the ore. This capping adheres to the ore and is usually blasted, although it may sometimes be removed with crowbars.

Holes are drilled through the ore at 3 ft. centers, and are shot with 1½ to 1¾ sticks of 15 per cent dynamite, which is worth about 9 cts. per lb. This means the drilling of 4 lin. ft. of hole for each cubic yard of ore excavated and 1¼ lbs. of dynamite used per cubic yard. The ore breaks in slabs of varying sizes, the large pieces being broken with sledges. The broken ore is loaded into tubs or skips by a small steam shovel, and hoisted by means of a derrick into railroad cars on the bank. For the loading of the skips a Vulcan Little Giant Shovel with a dipper of 1¼ cu. yds. capacity is used. It requires a crew of three men and burns 1½ tons of coal per day of 10 hours. This shovel has excavated as much as 300 tons of ore per day. The ore weighs 225 lbs. per cubic foot or 3 tons per cu. yd., thus giving a yardage handled per day of 100 cu. yds. This output when it is considered as working in hard material against a breast less than 3 ft., is very good. The derrick for operating the skips is mounted on a broad gage car. This derrick is operated by three men and burns ¾ ton of coal per day of 10 hours. The approximate cost of breaking up, loading and handling the ore per day, assuming an output of 30 cu. yds., is as follows:

Foreman	$ 3.50
Drilling	12.00
Explosives	3.37
Shovel Crew:	
Shovel runner	2.50
Cranesman	2.00
Fireman	1.75
1¼ tons of coal at $3.50	4.37
Derrick Crew:	
Engineer	2.50
Winchman	2.00
Fireman	1.75
¾ tons of coal at $3.50	2.62
6 laborers at $1.30	7.80
Plant (estimated)	6.00
Total	$52.16

This gives a cost per cubic yard as follows:

Foreman	$0.116
Drilling	0.400
Explosives	0.112
Loading	0.354
Derrick Handling	0.296
Laborers	0.260
Plant	0.200
Total	$1.738

Making a total of $1.74 per cu. yd.

We are indebted to an article by Mr. Edwin Higgins in the "Engineering and Mining Journal" for the information upon which this article is based.

Cost of Manufacturing Pig Iron and Steel Rails.—At a recent hearing before the House Ways and Means Committee, Elbert H. Gary, chairman of the board of directors of the U. S. Steel Corporation, gave the following cost data. He said that the average mining cost in the Lake Superior region is $1.43 per ton of iron ore, including mining cost, depreciation and royalty. The freight to the lower lake ports, such as Chicago, averages $1.45 a ton. He said that, eliminating the profit all along the line, the cost of producing pig iron in America is $12.65, itemized as follows per ton of pig:

Iron ore	$ 8.62
Coke	1.15
Limestone	0.49
Scrap	0.16
Cinder and scale	0.11
Labor, materials and operating cost	1.35
Depreciation	0.40
Total	$12.28

This total does not check with the above given total of $12.65, nor does it check with another statement by Mr. Gary to the effect that the average cost of producing pig in all the plants of the U. S. Steel Corporation is $15.30 per ton. Probably the $15.30 includes interest on investment and overhead charges.

Mr. Gary gave the cost of steel rails as follows, per ton:

Pig iron	$15.06
Converting pig iron into steel ingots	2.88
Converting ingots into rails	3.22
Depreciation	.84
Administration and taxes	.81
Total	$22.81

Roads and Streets Section

Note: This Section is devoted to methods and costs of road and street construction. It will cover road building in all its details, the construction of pavements, sidewalks and gutters, the testing and use of paving materials and the machinery and tools used in road building and paving.

The Construction of Sand-Clay Roads.*

BY W. L. SPOON.†

We are here to discuss the clay and sand road because it is of such wide application and so often the only road possible or within the reach of the community.

At the outset, let us define a sand-clay road and then analyze and discuss the constituents. A sand-clay road is a road whose wearing surface is composed of grains of sand in contact and with the voids filled with clay as a binder. Bear in mind that the grains of sand must be in contact to fulfill our definition, and this implies that they are to have the greatest possible surface contact. In other words, they must be wedged and interlocked into the closest relation in order that the greatest stability may exist along with the greatest resistance to displacement. In short, it is exactly the same relation that exists in macadam.

With this we see that angular sand is better than round, that coarse is better than fine sand. Hence, whenever it is a case of hauling sand, it is very important that we select the coarsest, sharpest sand obtainable. In most instances, however, it is the clay that is hauled and the sand, already in the road, must remain and form the sand part of our composition with clay. A moment's reflection will satisfy one that sand which has lain in the road for years and has been subjected to the grinding process of travel over it is well worn and round. This we would not expect to give as good results as a fresh, sharp sand and it does not. However, if we build upon it, as a foundation, it is as satisfactory as any. The chief function a sand foundation serves under a road is to provide ample drainage, which is exceedingly important. Often the success of a road depends solely on its under-drainage. It is not generally known that quicksand may be rendered firm by under-drainage which removes the hydraulic pressure due to the upward flow of water that may originate from a spring or seepage. Try under-drainage and note results.

Returning to our definition of a sand-clay road, we are told indirectly that there are voids between the grains of sand, no matter how closely they may be interlocked. Their faces are not exact counterparts and all face angles are not made to fit with exactness into the space formed by the adjacent grains. If it were possible to produce such a voidless composition of sand alone, we would have a monolith. This is however impossible without the addition of some void filling substance. The volume of these voids then becomes a matter to carefully consider, and for the purpose of making an ocular demonstration of the relative voids, we will use two glasses, one filled with water and the other with clean sand.

Now observe that the water taken is the measure of the voids in the sand. No amount of pressure within the strength of the constituent grains of sand or other treatment will express all the water from the sand voids. The closest relation is obtained by a gentle tapping continued for a long time. Observe this fact for it is significant alike for all grades of sand. But our definition states that the voids shall be filled with clay and not water, as has just been done in your presence. How shall it be done practically?

Before attempting to answer the question just raised, it might be well to discuss the physical properties of different clays so as to determine whether it will be worth while to attempt to use any particular clay as a void filler. The reason for this is our definition which says that the clay does more than merely fill voids—it acts as a binder to hold the grains of sand in place. We might mention another function of the clay filler and that is the duty of keeping the water out; its non-absorbent qualities. Usually any clay that is a good binder is also a good non-absorbent and will withstand wet weather. But if it absorbs water readily it will either expand and thus separate the grains farther, thus destroying the contact relation above described, or it will readily wash out and leave the sand without a bond. So in the selection of a clay always use the best available. There is no better way than to make a careful inspection of the roads in the neighborhood. If none are found good in their natural state, it is pretty sure evidence that there is poor prospect of any very great improvement by hauling material from one part to another on the same road. In such cases it will be necessary to look elsewhere than in the road for material to improve it.

I shall not attempt to give you an analysis of the mineral constituents of clays. It would be utterly worthless to the average road builder in his effort to produce a good road to tell him the formula for pure clay and point out to him the dozens of impurities that are nearly always found in connection with it. Everyone knows what you mean when you mention clay. They know what sand is and what loam is. Everyone knows that clay when dry enough to pack makes a better road than when wet, that sand when wet is a better road than when dry. Hence by reasoning from cause to effect we would [illegible], that by combining these two elements, sand and clay, we should partially neutralize the bad qualities of each. We would reach this conclusion were there no proofs of it in existence, but there are proofs of the correctness of this conclusion existing in every section where sand and clay alternate.

There is one property of clay that we should understand and test. The property referred to is its shrinkage. It may be tested in this simple way. A lump is taken and made thoroughly wet and then divided into three pieces. The first piece is made into a ball and left to dry, the second has 50 per cent of sand added to and thoroughly mixed with it and the mass then made into a ball and left to dry. In like manner 75 per cent of sand is added to the third and it is allowed to dry. When dry observe the cracks if any have formed in these balls. Notice that the cracks are measures of the shrinkage in the clay and likewise the measure of the expansion when the water is again restored. You will probably find that the ball with no sand added cracks most and the one with the most sand in it cracks least, perhaps none. To make a road it must have sand sufficient to prevent cracking. We may further test our three balls of clay by submerging them in water and observing how long it requires for them to slake and run down. The longer it takes to melt down the balls the more powerfully the clay resists washing and the more firmly it binds the sand.

With the above brief discussion of sand and clay we are ready to take up at this point the best practical method of mixing the sand and clay together. It was said above to make the clay wet to add the sand. This is always necessary, whether on the road or in the laboratory. True the clay might be pulverized and the sand added but until the mass is fully saturated there is no tendency at all in the mass to bond. This mysterious effect of water is an absolute necessity in the void filling process. To make a long story short, the clay and sand may be brought together in the dry state, but the final mixing must be effected when both are thoroughly wet. This is best done by the plow and harrow. If there is much sand already in the clay it may be hauled on the road and spread evenly by plowing to break up the hard places and then harrowing to render the surface of even hardness and without depressions. The mixing is often left to be effected by travel, but this invariably results temporarily in a very messy road. Finally, however, it compacts and forms a hard road but it will need frequent machining to produce a smooth surface.

The proportion of sand and clay to be brought together cannot always be determined at first. In fact, there is no better way than to approximate it as nearly as possible and then watch the manifestations. If it continues to mush up in wet weather, there is clearly a deficiency of sand. If it breaks into loose sand there is need of more clay to hold it together and this must be added. Keep the definition of the sand-clay road in mind and work to that end.

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*From an address before the Roads School, held at Waterloo, Ia., Aug. 16, 1908.

†Road Expert, U. S. Office of Public Roads.

Annual Meeting of the American Society of Civil Engineers.

The 56th annual meeting of the American Society of Civil Engineers was held on Jan. 20 at the house of the society in New York city, with an attendance of about 700, President, Mr. Charles Macdonald, presiding.

The report of the board of direction for the year ending Dec. 31, 1908, showed a total membership of 4,824, of which 2,370 are members, 1,619 are associate members, 642 are juniors and the remainder honorary and corresponding members, associates and fellows. The reports of the secretary and the treasurer showed that the receipts for the year were $126,381.78 and disbursements $93,299.18, leaving a balance on hand of $33,082.60. A payment of $10,000 was made on the mortgage debt, reducing the latter to $155,000.

The committee on prizes reported the following awards for the year ending with July, 1908: Collingswood Prize for Juniors, to Mr. Diedrich W. Krellwitz, for the paper on "Reinforced Concrete Towers"; Thomas Fitch Rowland Prize, to Mr. Edward E. Wall, for the paper on "Water Purification at St. Louis"; Norman Medal, to Mr. C. C. Schneider, for the paper entitled "Movable Bridges." The committee also recommended that the excellence of the report on the "Effects of the San Francisco Earthquake of April 18, 1906, on Engineering Construction," prepared by committees of the San Francisco Association of Members, be recognized in some manner by the society and accordingly the board of direction adopted resolutions expressing the appreciation of the society for the careful and valuable work of the committees.

The annual convention was announced to be held in the Mt. Washington Hotel, Bretton Woods, N. H., July 6-9, 1909.

The election of officers, in which 1,083 votes were cast, resulted in electing the members proposed by the nominating committee. They are: President, Onward Bates, Chicago; vice-presidents, George H. Pegram, New York city, and Emil Swensson, Pittsburg; treasurer, Joseph M. Knap New York city; directors, Francis L. Stuart, New York city; Samuel C. Thompson, New York city; William G. Wilkins, Pittsburg; Arthur N. Talbot, Urbana, Ill.; William M. Gardner, Memphis, Tenn.; Horace A. Sumner, Denver, Colo.

Work on the masonry of the Shoshone Dam of the Wyoming, Shoshone Irrigation Project was suspended for the winter on Nov. 30.

The Work of the Municipal Asphalt Repair Plant of Indianapolis, Ind.

Work on the municipal repair plant of Indianapolis, Ind., was begun on April 16, 1908, and on June 16, 1908, the first asphalt mixture was turned out. The plant was made by Werthington & Berner and has a capacity of 1,200 sq. yds. of 2-in. asphalt. The total cost of the plant, one 5-ton steam asphalt roller, four dump wagons, fire wagons, office building, roller, stone dust and tool sheds and all tools necessary to carry on the work, amounted to $20,557.68. This also includes the cost of grading off the yard for plant, putting brick driveway under mixer and cement floor around cold sand elevator. The plant itself cost $15,525. Between June 16 and Dec. 31, 1908, there were turned out by the plant 14,798 boxes of surface mixture for city work and 1,893 boxes of surface mixture for resurfacing West Michigan St. There were also turned out 373 boxes of binder for city work and 1,357 boxes of binder for the West Michigan St. resurface work, making 1,730 boxes of binder and 16,691 boxes of surface, or a total of 18,421 boxes of mixture turned out in this time. During the above period repairs to 52 different streets were made, a total of 103,743 sq. yds. of surface and binder being turned out by the plant and laid. In addition employes of the plant laid 4,467 sq. yds. of concrete. The concrete was used to bring the base up to grade. For the city work 4,026 sq. yds. of 2-in. to 6-in. concrete were necessary, costing $1,399.66 or $0.347 per sq. yd. On private cuts 441 sq. yds. of 6-in. concrete were constructed at an average cost of $1 per sq. yd.

A summary of the output shows that 75,428 sq. yds. of surface mixture were turned out for actual repair work for the city, 7,540 sq. yds. were for private work and 7,504 sq. yds. for resurfacing West Michigan St. A total of 9,504 sq. yds. of binder was also turned out for resurfacing West Michigan St., and 1,767 sq. yds. were used for private work. This private work was done for local water, gas, electric, street railway and plumbing companies, and for it the city received $12,330.72.

The largest single piece of work was the resurfacing on West Michigan St., with a 2-in. asphalt surface and a 1-in. binder. This street was paved by contract in 1906 and was still under guarantee. It was resurfaced with Trinidad Pitch Lake asphalt. The total cost of removing old material and relaying 9,504 sq. yds. of pavement on this street was $10,763.83 or $1.132 per sq. yd.

The total cost of all work done, exclusive of the West Michigan St. resurfacing, amounted to $53,301.92 for 82,968 sq. yds., or $0.642 per sq. yd.; this includes interest on investment of $20,557.68, for 6½ months at 5 per cent and depreciation for same period at same rate.

Deducting $12,330.72, which the city received for the 7,540 sq. yds. of private work, makes the city's own repairs, including the extra concrete, cost $40,971.20, for the 75,428 sq. yds. of actual city repairs and 4,026 sq. yds. of concrete, or 10.543 cts. per sq. yd. Deducting the cost of the extra concrete, $1,399.66, on account of not being strictly asphalt repairs, would leave the actual cost to the city of its own asphalt repairs, $39,571.54 for 75,428 sq. yds., or $0.524 per sq. yd. This includes all expenses attached to work, superintendence, interest on investment, depreciation on plant and tools, insurance, lease on ground, etc. The work was done on the same basis as other city work, eight hours per day, and was performed under the most favorable conditions as a great many of the repairs were large and close together. Only one day was lost account of rain, and four days lost waiting for material.

Only seven hours were lost on account of the plant not being ready when called upon: two hours on account of the breaking of a driving pinion and five hours for replacing brick work in the furnace under the sand drier. This, it will be noted, is a very small loss of time when it is considered that the plant turned out 18,421 boxes in all.

Maltha California asphalt was used for the most part on the repair work; but on account of the West Michigan St. being under guarantee and specifications calling for this material, Trinidad Pitch Lake asphalt was used in its resurface.

Petroleum residuum was used as a flux and the very best of material and workmanship were used throughout.

The cost of materials used in the plant was as follows:

California asphalt, $23 per ton.
Trinidad asphalt, $29 per ton.
Limestone dust, $3 per ton.
Residuum oil, average 5 cts. per gallon.
Sand, 90 cts. per cu. yd.

Common labor was paid 20 cts. per hour, skilled asphalt men received $2.50 per 8-hour day, teams were paid for at rate of $3.50 per day, roller engineers received $3.50 per day, and foremen received $4 per day.

The plant has been in charge of Sam. R. Murray, Superintendent, to whom we are indebted for the above information.

Approximately 315 lin. ft. of advance were made in Gunnison Tunnel on the Colorado, Uncompahgre Valley Project of the U. S. Reclamation Service during December, leaving 3,500 lin. ft. yet to be excavated. Practically all of the advance of the month was made in the Cedar Creek heading. This heading has been carried on in dry granite. The average flow from Cedar Creek portal during December has been 10.3 second-feet; 325 lin. ft. of concrete lining were placed during the month in the Cedar Creek heading. At the end of December the Gunnison Tunnel as a whole was 73 per cent completed.

Unclassified and General Articles

Note: This section is devoted to methods and cost articles on construction work not properly coming under any of the preceding classifications.

The Young Civil Engineer.*

BY EUGENE W. STERN

The question which a young man keeps asking himself continually through his college days, and especially just before he graduates, is, "What shall I do next?" It is a very important question, and one that should be carefully considered, for this is really a critical stage in his career. I shall try to help a little by drawing from my own experiences, confining my remarks to the work of the civil engineer, that being the profession I have followed.

Now what line of work or specialty is the young graduate aiming to follow later in life? Does he wish to be in professional practice as a consulting engineer, or be the engineer employed by a railroad or other corporation or contractor, or does he wish to engage in contracting or manufacturing?

This question need not be answered at once, nor can it be until he has had some years of varied practical experience and is able to judge for himself.

Now I think it will be conceded that to be a successful engineer or to be really successful in the broad sense in any of the higher callings, a clear knowledge of a large area of life should be acquired, because only this can give breadth and poise and ability to handle large problems and develop in one executive ability and what may be called the ethical qualities, or qualities of leadership, as distinguished from the technical.

Technical qualifications there must be, but these alone will not place one among the chosen of his profession. There must also be the ability to inspire confidence in those desiring to make use of one's services, which confidence can only be based on character, temperament, and training, and the ability to inspire employes with a love of system and order, to maintain discipline without harshness, and economy without parsimony.

There must be endurance of mind and body, and adaptability, thoroughness, efficiency, intensity, and imagination for possibilities. Having thus briefly outlined the necessary qualifications for the successful engineer as they appear to me, let us see now how the necessary preliminary training may be obtained without too much loss of time.

The young engineer, when he graduates at the University of Toronto, has a splendid technical foundation. I do not believe a better one can be obtained anywhere else. He has been thoroughly trained in the fundamental principles of his profession, and no college or university should try to do more than this. There may be post graduate work along special lines of investigation, it is true, but the real post graduate work can only be done out in the world when he commences to take a hand in the game of life.

The college cannot place responsibility on one's shoulders, whereas as soon as practical work is begun this burden immediately commences to be felt, even if the position held is a very subordinate one.

In college the young engineer has just commenced to learn engineering, having completed only the ground work of his education, and he should begin at the bottom in practical work.

Such was the advice given by Dean Galbraith twenty-four years ago to our graduating class, and my experience has been that there could have been none better.

The first years after leaving college, therefore, should be spent in obtaining experience, as broad as possible, just as the young graduate physician does in going from one hospital to another to improve himself and broaden his training.

In our profession in the early stages, the old motto about "The Rolling Stone" does not apply. While the young engineer does not gather moss he gathers what is much better, experience—experience of the world, experience of men and of things, and his corners get rounded off.

It was just for this reason that in former days the artisan, having completed his term of apprenticeship, started out as a journeyman, to improve himself by travel and variety of experience through contact with the outside world in different places before settling down to his vocation.

The young engineer, therefore, should commence at the bottom, seeking that employment which will bring him out on the work, so that he can see how engineering construction is actually carried on, and how men are handled. He should learn as early as possible to understand men, not only the man with the pick and shovel, the iron erector, or the concrete mixer, but also the man above him. This knowledge cannot be acquired too early, nor can the subject be studied too carefully. It is of much greater importance to his future advancement than technics alone.

He will soon learn some fundamental things. He will find that the day laborer is a human being, having all the human weaknesses of character which we have, perhaps more accentuated on account of his lack of education, but having at the same time a sense of right and wrong. It will be found that he can be reasoned with and under proper leadership take pride in his work.

It will be found that the man who is able best to direct these men is not the loud swearing boss, but the quiet mannered man of firm character, who thoroughly knows his work, and gets it done right without much friction. He has a pleasant word for everyone who is doing his duty. And those who are not doing their duty are not on the job; but let it not be forgotten that this type of leader knows his work thoroughly. In his spare moments he is thinking out methods of how to economize in labor and how to protect his men against accidents and also how to conserve his employer's interests; he is never found drinking with his men; they must respect him.

There are such men as these, born leaders, on all kinds of work—in the back woods, on construction, and in the shop. Even if one never becomes a contractor nor employs labor, he must learn to appreciate this type of man, because some day when he is high enough up there will be such men under him, and he must know how to win their respect and confidence.

The engineer may be ever so successful as an office man, still some day he will find that his lack of knowledge of men is a very serious obstacle in his upward career, for an engineer to rise to the top must be a leader among men.

My advice, therefore, on starting out in life to the young engineer is that he should not put on any academic frills or patronizing airs. There will be very unpleasant experiences otherwise, and such deportment is a great handicap. He should be modest and thorough. If he is of the right stuff he is bound to come up, without any such useless accessories.

Now, what kind of work will enable one to gain the best experience in the shortest time, for mass of experience alone does not count unless it is broad and varied.

Railroad construction on heavy work, especially in unsettled countries or out-of-the-way places, is, I believe, the very best kind of experience to get immediately after leaving college, because one gets up against first principles, as it were, and sees how things are done from the very bottom.

The life breeds self-reliance and disposition to stand physical hardships, both of which are indispensable, and should be learned early, and the staff is thrown into more intimate relationship than in more settled communities. Besides railroad construction will enable one to see all kinds of work under way—the surveying, the clearing of the timber, earthwork, rock excavation, masonry, concrete, pile-driving, bridge building, track laying, and ballasting, and perhaps tunneling, and it will be a life out in the open air, and the further away from civilization for a time the better the experience.

It may be necessary to commence the work in the wilderness, where even food supplies at first may have to be brought in on the backs of men, exemplifying the earliest and most primitive methods of transportation; and when the work is finally completed and the welcome locomotive appears at the end of track, one engaged in such work will have seen the quick evolution in a few short months, from the most primitive to the most advanced methods of transportation, made possible by the gradual progress of science throughout the many centuries, by the knowledge it has given the modern engineer to enable him to control the forces of nature for the benefit and use of mankind.

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The lessons thus learned are never forgotten. Often do I find myself recalling with profit some experience gained on my railroad and survey work of many years ago. Even the hardships, the rough life, the plain food (and sometimes even the lack of this), the mosquitos and black flies and other things, are remembered with pleasure, for it was a life of strenuous work along the blazed trail, through the unknown forest and over the hills, and it was a struggle with the elemental forces of nature, and somehow most of us have enough of the primitive man in us to instinctively enjoy what our ancestors had to do.

After having two or three years' experience on railroad or other constructional work in a more or less subordinate position, it is time for a change back to the office; and I would suggest entering a bridge or structural shop, commencing in the draughting-room on shop drawings.

I have suggested a bridge and structural shop for the first experience at the shop, because the training there obtained is fundamental. All the methods are generally developed to a high degree of refinement, and economy has been very carefully studied both in manufacture and handling of the material.

A large concern is not desirable, because the detailing work is very much sub-divided; however, a few months' experience in such a place would do no harm, if only to learn their methods; but in a smaller concern there is more chance of seeing what is being done in the shop, and very often it is possible to be sent out on the erection.

One will be able to learn the fundamentals of shop work at first hand, such as template and pattern-making, the use of the tools, the handling of the material by cranes and derricks, and the making of erection plant and rigging.

In the office the instruction is also fundamental, and the knowledge gained applies to many branches of engineering outside of buildings and bridges.

It must not be thought for one instant that a draftsman is an engineer. An engineer must be a draftsman, just as he must know a good deal about surveying, although a surveyor is not necessarily an engineer.

He should spend every moment of his spare time in watching the work he details go through the shop, and, if possible, should see how it is erected. In my early days I used to put in the time after drafting hours, and even at nights, when the shop was working overtime, in the shops, in order to get posted on the process of manufacturing. No reasonable employer will refuse this permission, and if such is not granted I would advise a change to some other establishment. It has been my experience that the high grade employer was very willing and anxious to have his office men take an interest in such things—he is looking for just that kind of men.

One should be punctual, and not be the last to come in and the first to quit work. He should be diligent and intense in his work, and not loaf or "soldier" like the old fellows—they remain draftsmen all their life. He should be thorough, using great care to be exact when necessary. For instance, very often drawings may be freehand sketches if the figures are correct, and all the information given. Shop drawings, nowadays, are largely conventional. It is not really drafting in the broad sense of the word at all; therefore, do not waste time on unnecessary work, but be very careful not to omit information that the man in the shop needs. These remarks do not, of course, apply to scale drawings, which should be carefully and neatly made.

It is of great importance to know how to letter neatly and rapidly. It very often aids one to obtain the first position in the drafting-room, for very likely the first question asked the applicant is, after having stated, that he has had a technical education, is to see samples of his drafting, and if the lettering is done neatly, not only may it get him a position, but secure his advancement much more rapidly from the drafting of shop details to the making of general plans.

It is not nececsary or advisable to stay for months on shop details of simple work. After the routine is acquired, one should try to get advanced to more difficult work by winning his employer's confidence in his ability to do it.

He should not get despondent if, by reason of lack of openings, he has to stay longer in a subordinate position than he feels he ought to. He will know, if he is honest with himself, when the time comes to make a change to another employer.

He should be very careful, however, not to change unless for a very good reason. "Stickativeness" at the right time is a valuable asset, but when he does leave he should try his level best to make his departure a source of regret, rather than of joy, to his former employer.

While at the bridge shop the method of organization should be thoroughly studied. It is a splendid opportunity, and should not be lost.

Carnegie was once asked to write an article on Organization. He said he would, but his price would be very high. "How high?" was asked. "Five million dollars," was his answer. The knowing how to create such an organization as the Carnegie Steel Co. was worth that amount to anyone who really wanted to know. He further said: "You may take all the machinery, all the plant, all the business, away from the Carnegie Steel Co., but leave me my staff and organization, and I will have it all back in five years." He has often said that his success in life has been due to his knowledge of men.

The knowing how to perfect an organization of human machinery is the most valuable knowledge one can have, and exceeds technical qualifications, but one must know the technics in general to be able to perfect an organization.

One should stay at the shop long enough, if he ultimately thinks of becoming a bridge or structural engineer, to know how to design, detail, build in the shop, and erect buildings and bridges. In my opinion, no engineer is thoroughly competent to design unless he knows also how to construct the work which he designs.

After being at this work three or four years, and having already been on construction two or three years, the young engineer will have completed the bottom course of his foundation in practical work. He will have been up against first principles, as it were, in both construction in the field and in the shop. He should now look about him, and try to see whither he should begin to steer. He will by this time be able to tell from his own experiences, whether or not he wants to remain a professional civil engineer with some specialty ultimately in view or whether or not to go into some line of manufacturing work or contracting.

If at this time he has the means to travel he should spend a year abroad if he intends being a professional engineer, studying European methods and designs. This study should be abroad and far-reaching.

He need not hesitate about engaging in manufacturing or contracting work if he has the taste for it. The technical training and practical experience already obtained are a splendid foundation for this. He will be able to tell when the time comes whether or not he is fitted for this kind of work. One's temperament has a great deal to do with his success as a contractor or manufacturer.

It is of value to know something about bookkeeping and stenography might be valuable, as there are many cases where private secretaries have been able to rise to very important positions.

Another important thing is the keeping of costs of all kinds of work. My practice has been to keep these on regular card index-filing cards. The cost memos should, to be of any value, record not only the amount of the material used and the price per unit for this material but also the number of hours and rate of wages of the different kinds of labor

The salary which an engineer receives during his first years is of the least importance. In seeking employment it should be the value of the experience in building his foundation of knowledge which should count, unless, of course, there are special reasons why he should earn as much salary as possible.

I do not mean to say he should be satisfied with a nominal salary or less than what is the prevailing rate of compensation for the same kind of work. This he should obtain, as he would be doing both himself and his profession an injustice if he does not. What I mean to say, however, is that if two positions are offered, in one of which the salary is less than the other, but in which there is a chance of obtaining more varied practical knowledge and ultimately securing greater salary, the former should be selected instead of the latter.

Each position, no matter how subordinate, should be looked upon as a stepping-stone to something better, and every experience, even if unfortunate, be remembered, for such lessons are of great value. One actually learns more from his failures than from his successes.

I have been asked frequently by young engineers if they should accept positions in the tropics in unhealthy districts, and my advice has always been not to do so, for one should not handicap his whole future career by risking his health in his early years, and it is not at all necessary. There are plenty of positions open in Canada and the United States, and there is always a scarcity of thoroughly competent men to fill them.

As to positions in Municipal Bureaus or under the Government, I would advise against these in the earlier stages of practical work, because I think that broad and strenuous experience is better gained elsewhere. It is time enough after the foundation has been thoroughly laid to step into a position under Government, if it is desirable.

And now, just a few words more of advice to the young engineer. He should not drag out the work he has to do, in attempting a degree of refinement which it does not warrant, yet he should not get careless; when he feels that he is getting that way he should shake himself up a bit, or the boss, if he is of the right kind, will surely do so. He should apply the rule of common sense to everything he does. After having completed a design, for instance, let him forget all about the theory and mathematics involved, and try to look at it from the standpoint of practicability—the shop processes, the erection of the work in the field. Let him seek eagerly the results of practical experience, and listen with respect to advice of even the rule of thumb practical man who knows his work. He should not try to get another man's job. He should be loyal to the man above him. If he cannot be so on account of this man's lack of integrity, he should either ask for a change or resign. But only a peculiarity of temperament in his employer is not a sufficient excuse for a change. One must learn to be tactful and to get along with people both above and below him.

A tendency to change one's position too often without just cause shows a lack of steadfastness.

An employer always wants to know why one seeking employment has changed from one position to another, and the reasons given are carefully considered in the estimate he forms of the applicant's character.

I would advise in making application for positions to clearly but briefly state exactly what the previous positions have been, and the experience obtained, and the reasons for leaving each of these.

A copy of a testimonial from each employer should be sent with the application. A personal interview is always to be desired if possible, as it enables the employer to "size up" his man.

The young engineer should associate himself with the local engineering club if one happens to exist, and should early join the Canadian or American Society of Civil Engineers, or both, and keep fully abreast of the times in technical matters. He should mix with those in other professions and with business men, and become known in the place where he lives. Besides, he should not neglect his general education, for after leaving college he has only commenced to be educated in the broad sense. His reading should be as diversified as possible—in history, economics, and general literature, so that some day he may become a well-balanced all-around man, not only a credit to the noble profession he has chosen for his life's work and to his Alma Mater, but also to the community wherein he lives.

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The grand total of excavation at all points on the line of the Isthmian Canal, from the day on which the Americans took control, May 4, 1904, down to the close of 1908, is 59,773,179 cu. yds. The yearly output has been as follows:

	Cu. yds.
May 4 to Dec. 31, 1904	243,472
Jan. 1 to Dec. 31, 1905	1,799,227
Jan. 1 to Dec. 31, 1906	4,948,497
Jan. 1 to Dec. 31, 1907	15,765,290
Jan. 1 to Dec. 31, 1908	37,016,693
Total under American control	59,773,179

During the month of December 12,500 cu. yds. of masonry were placed in the Roosevelt Dam of the Arizona Salt River Project by the U. S. Reclamation Service. This brought the dam to an average elevation of 85 ft.

Cost of Constructing a 66-in Brick Sewer at Gary, Ind.

The methods and cost of constructing a brick sewer of oval section, 6 ft 2 ins x 8 ft 11 ins in size, at Gary, Ind., were published in our issues of Aug. 5 and Oct. 7, 1908. This oval section changes to a circular section 66 ins. in diameter and then to a circular section 60 ins. in diameter which continue the sewer inland. The costs of the circular sections, 1062 ft. long, have recently been compiled from inspectors' and time keepers' reports by City Engineer A. P. Melton and Assistant Engineer E. M. Schetlow and are given us for publication.

The land through which the sewer passes consists of alternating ridges and marshes differing in elevation about 10 ft. The trench, therefore, varied in depth between a maximum of 21 ft. and a minimum of 11 ft., and averaged 17 ft. in depth. The material trenched was a fine sand saturated with water to a height of 13 to 14 ft. above the bottom of the trench. The water-soaked sand was very unstable, taking a slope of about 1 on 15 when unconfined.

The method of excavation was to take out a wide cut between natural banks to about waterline level, then to drive sheeting and excavate between it to subgrade. To permit excavation between sheeting the sand was freed of its water to below subgrade level by sinking batteries of well points and pumping. Full details of the bleeding plant were given in our issue of Aug. 5, 1908. The wide surface cut was made with a drag bucket excavator, with two objects, one to get a wide working space and two to reduce the depth of sheeting.

Construction was begun Aug. 1 and finished Oct. 1, 1908. Laborers on excavation, sheeting, pumping, etc., worked a 10-hour day; tenders, cement mixers and helpers to bricklayers worked a 9-hour day; bricklayers worked an 8-hour day; firemen on pumps worked in 12-hour shifts and excavating machine crews worked a 9-hour day. The costs of the various items of the work were as follows:

Drag Bucket Excavator Work.—The preliminary cut was about 30 ft. wide and from 4 to 10 ft. deep; there were 33,350 cu. yds. of excavation for the 1062 ft. of sewer or about 31.4 cu. yds. per lin. ft. The excavator worked 83.5 shifts and so averaged nearly 400 cu. yds. per shift of 9 hours. The cost of operating the excavator was as follows:

Item	Per 9-hr. Shift
1 engineman at $6	$6.00
1 fireman at $3.50	3.50
4 laborers at $2	8.00
Coal (estimated)	5.00
Oil, repairs, etc.	2.00
Total	$24.50

This gives a cost of 6.1 cts. per cu. yd.

of excavation and of 50.3 cts. per lin. ft. of sewer.

Excavation by Hand.—The excavation between sheeting, approximately 8½x10 ft., was done by hand, scaffolding the material from 3 to 5 times and an average of 4 times. The cost of the work was as follows:

Item.	Total.
Foreman, 51 days at $3.25	$ 165.75
Laborers, 2,184 days at $2.25	4,914.00
Total	$5,079.75

This gives a cost of 39.4 cts. per cu. yd., and of $1.25 per lin. ft. of sewer.

Pumping.—The pumping plant consisted of 3 No. 3 Emerson pumps drawing from the well points; 1 No. 2 Emerson pump taking water from the pools formed behind the drag bucket excavator; 1 duplex pump for boiler feed, jetting points, wetting brick, etc., and 4 30-hp. horizontal boilers mounted on wheels. This plant worked continuously. The cost of operation was as follows:

Item.	Total.
Laborers 464 days at $2	$ 928.00
Fireman 439 days at $3.50	1,536.50
Pipelinemen 1,238 days at $2.50	3,094.00
Foreman 27 days at $3.50	94.50
Coal 60 days at $15 (estimated)	900.00
Total	$6,553.00

This gives a cost per lineal foot of sewer of $1.61 for pumping. Charged entirely against the excavation between sheeting which was closely 12,893 cu. yds., the cost of pumping per cubic yard of excavation was 50.8 cts.

Sheeting.—The sheeting consisted of 2 x 8 in. x 12 ft. plank driven close on each side of the trench. This sheeting was braced apart by two 6 x 8 in. walling pieces set 3 ft. apart vertically and 6x8 in. x 8½ ft. cross-braces spaced 8 ft. apart along trench. The cost for sinking, bracing, pulling and bringing forward was as follows:

Item.	Total.
Labor, placing and driving, 392 days at $2.25	$882.00
Labor, pulling and bringing ahead, 182 days at $2.25	409.50
Foreman, 27 days at $3.50	94.50
Carpenter, 36 days at $3	108.00
Total	$1,494.00

This gives a cost for sheeting of 36.8 cts. per lin. ft. of trench and of 11.6 cts. per cu. yd. of excavation between sheeting. There were about 73 ft. B. M. of sheeting and bracing per lineal foot of trench, so that the cost per M. ft. B. M. was practically $5 for labor placing, pulling, etc.

Laying Brick Sewer.—The sewer was built of two rings of brick. The invert was built in 24-ft. sections. Wooden centers with lagging 16 ft. long were used in laying the arch and 2 men knocked the centers down, brought them forward and re-erected them as fast as 6 bricklayers could work. The cost of laying was as follows:

Item.	Total.
Bricklayers, 223 days at $10	$2,230.00
Tenders, 112 days at $3.75	420.00
Scaffoldmen, 111 days at $2.75	305.25
Mixers, 225 days at $2.50	562.50
Form setters, 100 days at $3.75	375.00
Laborers, 715 days at $2	1,430.00
Carpenter, 18 days at $3	54.00
Total	$5,376.75

This gives a cost of $1.32 per lin. ft. of sewer and of $5.28 per 1,000 bricks laid.

Backfilling.—The backfilling to a height of 2 ft. above the brickwork was done by hand and for the remainder of the height by a 1-cu. yd. Hayward clam shell excavator. The backfilling by hand called for 277 days' labor at $2 and cost, therefore, $554 or 13.6 cts. per lin. ft. of sewer. The cost of the clam-shell excavator work was as follows:

Item.	Per Shift.
1 engineer at $6	$6.00
1 fireman at $3	3.00
3 laborers at $2	6.00
Coal (estimated)	5.00
Oil, repairs, etc	2.00
Total	$22.00

There were 55 shifts worked giving a total cost of $1,210. In addition the drag bucket excavator was worked backfilling for 18 shifts at $24.50 making a total of $441. Lumping the work of both machines, the cost of backfilling was 40.6 cts. per lin. ft. of sewer and 6.8 cts. per cu. yd.

Materials.—The cost of materials was as follows:

Item.	Total.
1,018,000 brick at $5 per M	$5,090.00
3,054 bags Utica cement at 20 cts.	610.80
3,054 bags Universal cement at 35 cts.	1,065.90
Lumber (estimated)	600.00
Total	$7,369.70

This is a cost of $1.81 per lin. ft. of sewer.

Hauling Materials.—For about 3,000 ft. of the work all materials were hauled from the railway siding in 2 cu. yd. steel dump cars running on narrow gage track. The average haul was 1,700 ft. For the remainder of the work the hauling was done with teams; brick were hauled by subcontract for 70 cts. per M. Two teams were also employed throughout the work to haul supplies from local dealers and to haul coal to the excavaters when they were beyond reach of the contractors' railway. The cost of hauling was as follows:

Item.	Total.
Laborers, 767 days at $2	$1,534.00
Foreman, 52 days at $3.50	182.00
Brick, hauled by team at 70 cts. per M.	194.60
Teams, 100 days at $5.50	550.00
Total	$2,460.60

The cost of hauling was thus 60.7 cts. per lin. ft. of sewer.

Superintendence and General Expenses.—The costs under these items comprised the following:

Item.	Total.
Superintendent, 2 months at $150	$300.00
General foreman, 2 months at $150	300.00
Master mechanic, 1 month at $200	200.00
Clearing right of way	80.00
Waterboys, 160 days at $1.50	240.00
Handy teams, 52 days at $3	156.00
Total	$1,226.00

This gives a cost of 30 cts. per lin. ft. of sewer.

Summary.—Summarizing the costs of the work per lineal foot of sewer we have:

Item.	Per Lin. Ft.
Drag bucket excavation	$0.503
Hand excavation	1.250
Pumping	1.610
Sheeting	0.368
Laying sewer	1.320
Backfilling by hand	0.136
Backfilling by machine	0.406
Materials	1.810
Hauling materials	0.607
Superintendence and general	0.300
Depreciation of plant, repairs, etc. (estimated)	1.500
Total	$9.810

Cost of Concrete Bridges.—In a table covering 18 concrete arch bridges recently built in Philadelphia the contract price spread upon the span area—the clear span by the width—varies from $3.11 to $9.74 per sq. ft. and it varies from $1.73 to $7.39 per sq. ft. of area occupied by the ground plan to ends of wings, the latter extremes being not on the same bridges as the other two. The average of the lot was $6.25 per sq. ft. of span area and $3.50 per sq. ft. over all, most of them being single span bridges with long wings, and all being highway bridges designed to carry loads of 40 tons on two axles 20 ft. apart. All have ornamental concrete balustrades and washed granolithic surfaces and paved decks, with electrical conduits and manholes, and water pipe and sewer well-holes and some have pretty deep foundations. If the whole contract price be set against the yardage of the concrete in the structure the unit costs vary from $8.50 to $11.25 per cu. yd., averaging $9.75. Mr. Henry E. Quimby, Engineer of Bridges, Philadelphia, Pa., is authority for these figures.

Methods of Weighing Stone on Barges and Scows.

BY HENRY F. ALEXANDER.*

The following is a description of the methods employed to ascertain the weight of stone shipped on barges and scows from the Johnston Island, O., and Kelley's Island, O., quarries. At Johnston Island the scows used consisted of deck scows without derricks, deck scows with derricks and dump scows, 14 in all. Twelve of these belonged to Hughes Bros. & Bangs and two to Gaynor Bros.

At Kelleys Island the following types of boats were used: L. P. & J. A. Smith Co. (now property of Great Lakes Dredge & Dock Co.) had a fleet consisting of several old schooners that had been dismantled and converted into stone carriers, some common deck scows, and two steel derrick scows; the Edward Gillen Dredge Dock & Construction Co. had three large derrick scows; the Kelleys Island Lime & Transport Co. had two wooden deck scows, two steel deck scows and two steam barges. As it was not practical to weigh all cargoes on scales the following methods were used:

Usually the boats were "weighed in" once each season, sometimes oftener. This weighing in was done as follows: The stone was actually weighed over scales and then placed aboard the boat. The water displacement was closely ascertained at various times during the loading. Until about 6 or 8 years ago markings were made at the fore and aft part of the boat on the outside. These outside markings were not satisfactory except in exceptionally calm weather, something unusual on Lake Erie, especially in spring, consequently the following methods of gaging the displacement were adopted:

A hole was bored in the bottom of the boat. In this was tightly fitted a pipe of about 3 ins. in diameter. This pipe extended almost to the deck. In this pipe the water had free access. In the side of this pipe two holes were made and short pipes fitted, each with a throttle. Into these two pipes a glass tube was inserted and by opening the throttles the water had entrance to this glass tube. To the pipe or near it was firmly fastened a rod. On this rod were drawn cross lines 0.01 ft. apart. The feet were marked in large red numerals and tenths of a foot in smaller black numerals.

Everything being in readiness, the light gage readings were taken, i. e., gages were read before any cargo was aboard. Then 50 to 100 tons (according to size of boat) which had been weighed over the scales, were placed aboard and the gages again read and displacement noted. This reading of the gages was repeated at various times during the loading of the barge, the displacement always being noted. The displacement for any amount of tons was found as follows: The various gages, 2 to 6 (according to size of the boat), were read and their average found. This was before any cargo was aboard and was called the light gage reading. Then after a part or all of the cargo was aboard the gages were again read and their average taken. From this last average the first was taken, the difference being the displacement. The gages were placed fore and aft, only, in the smaller boats, near bow and stern, and as near the keel as possible. In larger boats there would be one gage fore, one midship, and one aft, and in the largest boats there was a gage at the fore, one midship, and one aft, all on starboard side, and one opposite each of these gages on port side, or 6 in all.

After the weighing in of a boat was satisfactorily completed, tables were compiled from the various gage readings and their corresponding tonnages and these tables were used for computing the future loads of this boat. These tables were computed for every 0.005 ft. displacement from the lowest probable loading to the highest. After a boat had been satisfactorily weighed in, all that was necessary to ascertain tonnage of a load was to read gages before loading, then place entire cargo and read gages again, deduct former from latter and refer to table.

Great care must be exercised in weighing in a boat. A capable man should do the weighing at scales and another experienced man should do the gage reading. The amount of water in the hold of the boats should be as small as possible and must be as near as possible the same during the entire weighing in. The work should be done in dry weather, if practical, as a heavy rain during the progress of the work will materially affect results. The work should be done where the sea is in at least a moderately quiet condition—the quieter the better.

Some boats, especially the larger and rigidly built ones, like "Derrick Scow No. 21" of the Great Lakes Dredge & Dock Co. fleet, and the stoutly built "Dwight G. Cutler" of the K. I. L. & T. fleet, can be much easier and more accurately weighed in than smaller and more flexible boats like the old dismantled schooners such as the "H. P. Baldwin" and others.

There are several advantages in computing tonnage by displacement over the method of computing cubic contents of cargo and reducing to tons. A few of these are as follows:

(1) The weight of a cubic foot of stone from one quarry is not always the same as of a cubic foot of stone from another quarry, even in the immediate neighborhood. At Kelleys Island quarries the writer found a difference of about 15 per cent in the weight of stone taken from two quarries not over a quarter of a mile apart, both limestone quarries. The stone from both these quarries was loaded at the same deck and usually a cargo consisted of stone from both quarries. The stone was usually of rough, irregular shaped stones. In view of the above facts it would be quite difficult to ascertain tonnage by measurement of cubic contents. In computing tonnage by displacement this difficulty was all avoided and an accurate result obtained, as on a deck scow the displacement per ton is same whether cargo consists of heavy stone, light stone or feathers. This does not apply to dump scows as noted below.

(2) Considerable care must be exercised in loading stone, even if all is approximately uniform in size and weight, so as to be able to accurately ascertain tonnage from cubical contents as the size of the voids depend on how well the loading is done. When computing by displacement all that is necessary is to keep the boat on approximately even keel.

In loading dump scows the displacement per ton varies considerably owing to size of stone, the smaller the stone the more tons will there be per foot displacement and vice versa the larger the stone the less tons per foot displacement. This is due to the fact that in dump scows the water has free access into the pockets and fills the voids in cargo and must be considered and its weight included. The smaller the stone the smaller will be the voids and consequently less water so that more tons of stone will be required per foot of displacement and vice versa.

In weighing in dump scows at Johnson Island the writer weighed one scow three times, once using large stone, once using a mixture of large and small and once with a load consisting of small stone. In the first instance above mentioned a certain displacement for the cargo was noted; in the second one about 10 tons more were required for same displacement, and in the third one about 10 tons more than in second, or a difference of 20 tons over first, all owing to size of stone. This boat only carried about 500 tons. We thus have a variation of 4 per cent.

While stationed at the two quarries above mentioned in 1903-8, the writer had charge of weighing in of 31 different boats of the various types mentioned at the beginning of this article. Most of these were weighed in once each season and some several times per season. After shipping over 900,000 tons of stone, distributed among these different vessels, the writer's conclusion is that the least satisfactory boat is the dump scow, and the most satisfactory boat for the quarry operators, the contractor, and the parties for whom the work is being done is a good, strong, well built deck scow, either with or without derricks, according to nature of the work being done.

The Chinese Government has decided to build two new dockyards, one for Pelyang and one for Nanyang.

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*Curtisville, Pa.

LETTERS TO THE EDITORS.

The Value of Cost Data in Preventing Reckless Bidding for Reinforced Concrete Construction.

Sirs:—I have read with interest your editorial and Mr. Wason's paper covering the cost of concrete construction as applied to buildings, and I wish to say, the reader is in thorough accord with the idea of placing reliable data or methods before the public with the object of getting the inexperienced contractor in line, that the wild and reckless bidding now indulged in, may be eliminated in whole or in part.

I do not think there is a competent concern now in the concrete construction business that has not at times been beaten by some inexperienced contractor, in fact, this seemed to be the rule rather than the exception during the past year owing, probably, to the fact that the scarcity of work forced many concerns to reach out and essay lines with which they were not familiar. There are, of course, some owners who will act on the advise of their designer and eliminate from competition those firms not thoroughly equipped or organized for this class of work, but the majority are otherwise and the man who can produce a low figure and can furnish a bond is the party who secures the work. The essential requisite of the owner is that the work be done and the "unimportant" fact of the contractor not being able to produce the work at his contract price is a matter that concerns the owner but little, always providing the surety bond is from a responsible company.

It is the writer's opinion that more concerns have lost money erecting reinforced concrete during the past four years than in any other type of construction that could be named and the basis of this unsatisfactory state rests upon published data that is not complete. Primarily cost data reports are of little importance as a basis for calculation unless the figures are accompanied by a drawing or written description of the work, specifying the size of the members, the character and design of the forms and the number of times the forms were used in the operation.

I do not think that the case is misstated when the assertion is made that each concrete construction is a separate operation and should be carefully considered before applying cost data gathered from previous operations. The spacings of members used in the building may vary but little from that of the previous operation, but that little variance may cause an increase form cost of 100 per cent.

Buildings can and are being designed that enable the contractor to use stock lengths for forms and the change of the members from floor to floor may be so planned that forms can be used with little alteration at least three or four times, but the same building can be designed with changed members on every floor necessitating more work and more lumber. We consider this matter very serious and in many of our buildings have obtained permission from the architects or owners to carry the columns, beams and girders at the same size through three floors, and have found that the excess cost of concrete and steel has been more than offset by the saving in form labor. In other words, panels of forms could be removed and used twice after being placed in their original position and the result accomplished without any cutting or alteration whatsoever.

If the present successful concrete contractors desire intelligent competition it will undoubtedly pay them to describe in detail each operation upon which cost data are published. To show the danger of too little information, I would state that on one of our recent operations we placed a concrete roof over a foundry, the total area of roof placed was practically 30,000 sq. ft. and the roof was a slab laid over the upper flange of 8-in. I-beam purlins. In this work, we used 2-in. surfaced southern pine for our forms supported on combination beams bearing on the lower flange of the purlins. This combination beam is a patented device of our own and when I say that our form cost including the lumber, erection and taking down of forms, averaged 3 cts. per sq. ft. of area, you can readily see that any other contractor using data such as this for a basis of a bid would put himself in hot water, as the best cost I can find in Mr. Wason's paper for this class of work is 4.9 cts. per sq. ft. By this, you can see the inaccuracy of published cost data if same is not accompanied by a description or drawing thoroughly illustrating the method of work.

For the benefit of any of our readers who are estimating concrete work, I would advise that the best method is to estimate the area of work to be formed and from this area secure the lumber and apply the erection cost. Show in detail the work to be erected and design in your estimate types of forms that can be used and carefully figure the number of times each type can be used. After this is done, all that is necessary is to apply a carpenter charge sufficient to build your units. Figure the erection and taking down of these units separate from the charge of building same as it is easy enough to secure the cost per M. ft. B. M. of lumber for the framing of the units, but I would not advise the placing of the units and removal of same to be estimated in terms of lumber. This part of the operation should be figured by area using as a unit a square foot of surface.

In estimating operations not similar to any that has gone before, it is usually safe to assume an organization for the form erection, allow wages paid for the class of men you wish to use in erecting forms and to carefully take each man's time and estimate how long it will require to do that portion of the work that will fall to the individual worker. After a little practice you will find that this is not as hard a proposition as appears on the surface, any one familiar with the speed of workmen can approximate very closely the time it will require to erect scaffolding and hoist forms into position, put in props or supports, etc. After having assumed the the amount of time it will require for a gang to erect the form, then use the same method to ascertain how much time is required to take down said forms and transfer the distance required to the next place of use. Adding up the time required for both these operations will give the total time required to erect and take down a form. From the amount of time required, you can secure the assumed cost and to secure your area cost, divide the number of square feet of concrete surface covered by the forms into the labor cost and the result is obtained. This method requires the work to be separate from the building of the units and is safe, as a little knowledge on the part of the estimater with labor will prevent him going astray, although I would not recommend such a method to a beginner. It is essential that some knowledge be had of results you can obtain with different classes of labor.

I would further urge that any published report of work be separate as to form cost and concrete cost. It is a very popular method to say that the forms cost so much per yard of concrete and any man who estimates his form costs from his yardage deserves to land in the junk heap and undoubtedly is headed that way. There can be no connection between forms and concrete in place, that can be expressed in terms of concrete, for example, 8 sq. ft. of wall surface forms may enclose 2 cu. ft. of concrete in a 6-in. wall, or may enclose 12 cu. ft. of concrete in a wall 3 ft. thick and under our method of erecting wall forms, the cost would not vary 2 per cent, a little more internal bracing being required for the latter than for the former wall. I have heard, time and again, contractors figure difficult work in concrete at a yardage price and I have seen lots of these contractors go on the rocks before the work was finished, but that is no consolation for the bidder who has figured his work with proper attention and has added a moderate profit.

Competition in any line of work should be encouraged. The more people after work, the more demand is created for that class of work and especially is this true in reinforced concrete construction and many a job has been talked up by us and landed by a competitor or vice versa. Competitors can be divided into two classes; those who are capable and those who are not. Being beaten by a competent competitor sharpens your wits and causes you to shake up the organization for better results as you know your competitor understands his business and if he can secure good work cheaper than you, you will have to cheapen your costs or be under a handicap in the future trials. To be beaten by a competitor who is incompetent, especially when one's figure is cut 20 to 30 per cent, fills you with disgust and you wonder why the keen business man will accept figures that are much below the average bid, but such is true in the majority of cases. To get away from this state of affairs, it will do no harm for those who know to spread information abroad and the writer, for one, is willing at any time to write or advise any person on any point in concrete construction in which he has had any experience, believing that methods and not costs govern the successful completion of the piece of work.

This preceding sentence brings up a matter upon which the inexperienced contractor should be cautioned, viz., that the securing of a job at a good price is not always the forerunner of the profits in your bank book, for unless the organization can carry the work through on your costs, your profits may go glimmering. Such an organization cannot be secured through newspaper advertisements, neither can one usually pick up a good man through labor agencies, in fact, my experience has been that the men most recommended to me were those least competent and it is now our practice to pick our superintendents and foremen from men who have worked in minor positions on our jobs and have become familiar with our methods. A good superintendent must be made and very few there are without failings and to learn these failings will prove costly.

To sum up, the writer is of the opinion that a contractor of no large experience, desiring to enter into concrete construction, should proceed with caution and seek advice from those capable of giving same, should study thoroughly all published data bearing on work and make the proper effort to study the methods used in actual construction. To do this, it will be necessary to visit many operations of various kinds and to make notes of each operation paying attention to the forms, their types, and the amount of labor necessary for erection. This is good practice and will stand you in good stead on your own work as often you may wish to check up your own gangs and a fair approximate cost can be obtained by the experienced man from watching operations of a gang for a stated time. Of course, it is necessary that this method be followed when the men are not cognizant they are being timed.

A great deal can be said on this subject by going into further detail, and I would like to see other construction people take up and discuss this subject through your paper as we all can absorb knowledge. Each day brings forth new data and each effort towards lower costs will bring results, as undoubtedly reinforced concrete construction will displace other types in future erections as the more we standardize our costs the more we hasten the use of this type of construction. Thanking you for your kindness in placing this matter before contractors for discussion and trusting that what I have written may be of some use on this subject, I remain,

Yours truly,

S. H. ANTHONY,

Manager Hindman Henderson Co.

Pittsburg, Pa., Jan. 21, 1909.

The Cold Springs Reservoir; a Comparison of the Bidding Prices with the Cost by Day Labor.

Sirs.—In looking over a note book today I found a copy of the prices bid on the Cold Springs Reservoir, Umatilla Irrigation Project, U. S. Reclamation Service. Remembering the article and cost tables in your issue of Dec. 16, 1908, I enclose the following as of possible interest:

The bids were submitted and opened June 28, 1906; forwarded to Washington and rejected as too high. The work was readvertised, and, I believe, a slightly lower bid than that of Sweeney & Holmes was received. The Puget Sound Bridge & Dredging Co. raising their bid as they considered the time limit entirely too short in which to do the work. Sweeney & Holmes did not bid.

BIDDING PRICES IN COLD SPRING RESERVOIR.

Item No.	Excavation for Dam Embankment.	Estimate cu yds.	Actual cu. yds.	S. & H unit	P. S. B. & D unit	Total S. & H	Total P. S. B. & D
1.	Earth	158,000	203,011	$0.31	$0.42	$ 62,933.41	$ 84,960.10
2.	Gravel	155,000	173,400	.45	.42	213,03[illegible]	198,177.90
	Excavation for Trenches, Wasteway, and Foundations—						
3.	Class 1	61,300	52,103	.40	.69	20,841.20	35,872.92
4.	Class 2	19,300	6,574	.60	1.53	3,944.40	10,058.22
5.	Class 3	3,100	3,938	1.25	2.70	4,922.25	10,632.6[illegible]
	Riprap. (a) up-stream slope (alternative bid "A").						
6.		12,000	....	2.00	3.37	(Not used.)	
7.	(b) Inlet, outlet and other work	80	64	2.00	3.37	128.00	216.00
	Rock-fill (a) up-stream slope (alternative bid "A").						
8.		8,000	....	1.50	2.70	.....	......
	(b) up-stream slope (alternative bid "B").						
9.		28,500	35,908	1.50	2.70	53,862.00	96,951.60
	(c) Down-stream slope, roadway, etc.						
10.		10,800		1.50	2.70		
11.	6" drain tile, lin. ft.	1,900	[illegible]	.50	.67	1,468.00	1,982.48
12.	8" drain tile, lin. ft.	600	2,937	.60	1.00		..
13.	8" jointed, lin. ft.	600	846 of 12" cement laid				
14.	Concrete, Class A	1,250		10.0	5.50	12,500.00	6,877.[illegible]
15.	Concrete, Class B	500		11.0	6.50	5,500.00	3,250.00
16.	Concrete, Class C	800	859.8	12.0	10.50	10,317.60	9,027.90
17.	Concrete, Class D	560	327.1	11.0	5.70	4,[illegible]79.40	1,864.47
	Total					$394,872.76	$180,951.29

One-quarter of the volume of the embankment was to be completed by Feb. 1, 1907. One-half by May 1, 1907, and the whole work by Nov. 1, 1907.

The contractors were inclined to believe that the Reclamation Service desired to do the work by force account. This, with the short time for construction, connected with the ability of the clause, "to the entire satisfaction of the engineer," to permit the engineer in charge of the work, if he so desired, to make puddle, the largest item by considerable of the work, cost the contractor most any price he desired, no doubt had its influence on the bids.

Cement for the concrete, steel for the reinforcing, gates, etc., were to be furnished f. o. b. Hermiston, for the contractor by the Reclamation Service, 1 cent per lb. to be allowed the contractor for handling and setting steel, etc.

The chute for the feed canal was not to be included in the contract, so a portion of the item of $12,370.84 "Feed Canal, excavation and chute," would have to be considered in making comparisons. Also the cement and steel.

Nothing is said in the article as to whether the plant was considered in any way. Also quite a number of government teams were worked.

It was also some months after Nov. 1, 1907, when the work was finished. I believe that the bid of Sweeney & Holmes compares very favorably with the force account work, as shown in the accompanying table.

Very truly,

W. H. HAYNE.

Portland, Ore., Jan. 15, 1909.

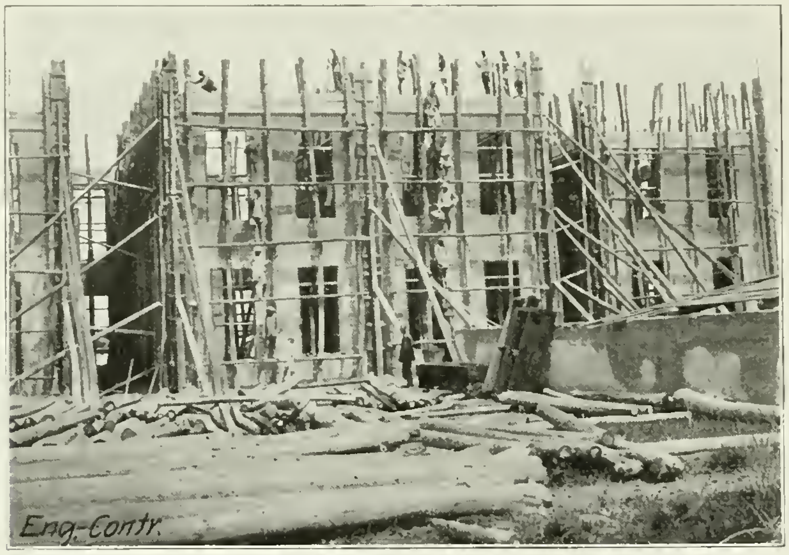
Note.—The dam was evidently constructed along the line of Bid "B." 12 in. cement pipe was used instead of the 8 in. tile laid with cement joints. Class "A" concrete was used in the main spillway wall, class "B" in the spillway wing walls, class "C" in the outlet and inlet works and class "D" in the training walls, spillway cut-off walls; and all not included in the other classes.

Preparations for closing the river at Laguna Dam on the Arizona-California Yuma Project by the U. S. Reclamation Service were completed on Dec. 9 and the dumping of rock from two steam shovels on the California side and five derricks on the Arizona side was begun. At noon on Dec. 21 the river was entirely diverted through the sluiceways and the closure has since successfully withstood a flood in the river of 10,000 second feet.

House-Building in China.

The accompanying illustration is of interest to engineers for several reasons. It shows a sand-lime concrete house under construction at Swatow, China. Timber houses are expensive in that section of China, owing to the fact that the white ant destroys timber quickly. The crude form of scaffolding shown would be expensive in this country, both in the amount of timber used and in the cost of handling such heavy logs. Men are shown placing and tamping the concrete, while two lines of laborers can be seen on the scaffolding, passing concrete in buckets to the workers on top of the building. We should do the same work with concrete barrows and a steam hoist.

All the wooden doors and window frames, jambs, wall plates and joists in this building were treated with Teredo proof paint manufactured by the Teredo Proof Paint Co., of New York, as a protection against the white ant. This paint is poisonous to animal life, so it has proven an effective protection to wood, and it is stated that it is the only compound that has stopped the terrible ravages of the white ant. Prior to the use of the paint on this building the Teredo proof paint had been thoroughly tested by the Hong Kong & Canton R. R. on their ties. The same paint has been used on the launch dock of the Imperial Customs at Swatow, as a protection for the piles against the Teredo and of the superstructure against decay.



House Building in China.

The U. S. Reclamation Service has been making surveys of the reservoir site, the dam site and the canals for a new irrigation project lying in the valley of the North Fork of Grand river in southwestern North Dakota and northwestern South Dakota. This project has been designated as the Bowman Project. The total irrigable area is about 10,000 acres.

Personals.

Mr. Fowler Mallett has opened an office at 2335 Waring St., Berkeley, Cal., where he will engage in the designing and supervision of building work.

Mr. W. C. Taylor has been appointed engineer of maintenance of way of the Spokane, Portland & Seattle Ry. and the Astoria & Columbia River R. R. Co., with headquarters at Portland, Ore.

Mr. Eugene H. Shipman, chief engineer of the Lehigh Coal & Navigation Co., has been appointed superintendent of canals of that company. with headquarters at Mauch Chunk, Pa. He succeeds Mr. John Ruddle, resigned.

Messrs. H. A. Butterfield of Goshen, Ind., A. W. Malone and C. A. Burnette of Warsaw, Ind., have organized the Triad Engineering & Construction Co., with general offices in Goshen, Ind. The company will make a specialty of the construction of electric railways.

Colonel P. A. McCarthy, of Lufkin, Tex., has resigned as chief engineer of the Groveton, Lufkin & Northern Ry. Co. to accept a similar position with the San Diego, El Paso & St. Louis Railroad Co., with headquarters at El Paso, Tex. The San Diego, El Paso & St. Louis R. R. Co. contemplate the construction of some 200 miles of standard gage railway from El Paso northeast to the Pacos River, New Mexico, with the probability of extending through the Pan Handle of Texas into Oklahoma.

Mr. Alfred P. Boller and Mr. Henry W. Hodge of the firm of Boller & Hodge, New York city, have been named by Andrew J. O'Reilly, President of the Board of Public Improvements of St. Louis, Mo., as engineers for the proposed municipal free bridge to be erected in St. Louis.

Brigadier General William P. Craighill. U. S. A., retired, died Jan. 18 at his home in Charlestown, W. Va., after a short illness. General Craighill at the time of his retirement from the U. S. Army was chief of the corps of engineers. He was at one time President of American Society of Civil Engineers.

At the annual meeting of the Iowa Engineering Society at Waterloo, Ia., on Jan. 13-14, the following officers for the ensuing year were elected: President, C. T. Wilson, Waterloo; Vice-President, T. R. Warrimer, Cedar Rapids; Secretary and Treasurer, A. H. Ford, Iowa City; Directors: L. H. Stone, Cedar Rapids, and C. P. Chase, Clinton.

Miss Alice Law, an employee of the Myron C. Clark, publishing Co., died on January 22 Miss Law took the engineering course at Purdue University, leaving that institution in 1902 to work as an engineering draftsman in Chicago. Later she engaged in book writing and editing with "Cement and Engineering News" and then with the "Engineering World," coming with the purchase of the latter paper to the Myron C. Clark Publishing Co. Her chief labor for the last two years was the compilation, under the direction of the author and publishers, of the "Pocket Book of Reinforced Concrete," by E. Lee Heidenreich. Miss Law's work in this book was of high character. She was a mathematician of ability, a linguist and a writer of more than usual promise, and her death is a sorrow to her fellow workers and friends.

Catalogs Worth Having.

Engineers and contractors should have on file the latest catalogs of machines, tools and supplies that they use. In sending for catalogs reviewed or advertised in this paper, you will confer a favor on us if you will write direct to the advertisers and state that you saw the catalog mentioned in ENGINEERING-CONTRACTING. If you are in the market for tools, machinery or supplies, tell us and we will notify promptly the leading manufacturers.

No. 1058. **"Anastigmatics."**—Bausch & Lomb Optical Co., Rochester, N. Y.

Under the above title the company named has issued a handsomely illustrated and printed pamphlet of 24 pages, explaining the nature and construction of their new anastigmatic lenses for photographic work. Engineers who are interested in photography and all who have to make photographs of structures and machines, particularly for purposes of illustration, will be interested in this pamphlet.

No. 1059. **Engineering Instruments.**—Bausch & Lomb Optical Co., Rochester, N. Y.

Aside from its copious illustrations, this publication is of interest because of the complete specifications given for the optical and mechanical construction of the various transits, levels and theodolites. The several features of the Bausch & Lomb instruments are explained in a brief manner, while an entirely original mining transit is cataloged for the first time. The distinguishing feature of this new instrument is a Prismatic Side Telescope, which is novel in construction. Also with this instrument the U-standard construction, together with a compass circle of the usual form is introduced.

No. 1060. **Conveying and Power Transmission Machinery.**—Skilling & Richards Mfg. Co., Chicago, Ill.

This 344-page, cloth-bound book is a complete general catalog of hoisting, conveying and power transmitting machinery. The company makes a specialty of conveying machinery for grain elevators and the catalog is profuse in examples of such machinery. General conveying machinery is, however, also liberally represented. Its completeness, with the large amount of useful information given, makes this volume a valuable one.

No. 1061. **Half-Round Steel Centers on Circular Conduit.**—Blaw Collapsible Steel Centering Co., Pittsburg, Pa.

In the construction described in this pamphlet the invert is concreted first and then the roof arch, the half-round center being used for both by simply reversing. Diagrams are given showing the mode of operation and there are numerous interesting views of sewer work in progress.

No. 1062. **Blocks.**—W. W. Patterson & Co., Pittsburg, Pa.

This is a 40-page catalog of extra heavy blocks for bridge erectors and general contractors. Extra heavy oil well blocks, and special blocks are also shown. Illustrations, tables of sizes and price lists are given.

No. 1063. **Turner System; Reinforced Concrete Construction.**—C. A. P. Turner, 816 Phoenix Bldg., Minneapolis, Minn.

This pamphlet presents a concise argument of the advantages of reinforced concrete for construction work and describes in some detail the mushroom system of reinforced concrete devised and exclusively used by Mr. Turner. There is a section on ornamental cast stone work and a large number of illustrations.

No. 1064. **Snell Concrete Mixers.**—R. Z. Snell Mfg. Co., South Bend, Ind.

The mixer described in this pamphlet is of unique construction, consisting of an open circular drum or barrel. The pamphlet describes the construction and method of operation and shows numerous illustrations of the mixer.

Only 558 horses and mules are used in the Canal Zone in the service of the Isthmian Canal Commission.

CONTRACT NEWS

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We shall welcome any news notes that our readers may send in. Notes of contracts awarded, bidding prices, etc., will be especially acceptable.

BIDS ASKED

Bridges.

Bids Open.		See Issue.
Jan. 28.	Cedar Rapids, Ia.	Jan. 13
Jan. 29.	Cincinnati, O.	Jan. 6
Jan. 29.	Cincinnati, O.	Jan. 13
Jan. 29.	La Prairie, Que.	Jan. 27
Jan. 30.	Beaufort, N. C.	Jan. 6
Jan. 30.	Dayton, O.	Jan. 20
Feb. 1.	Topeka, Kan.	Jan. 20
Feb. 1.	Greenville, Miss.	Jan. 20
Feb. 1.	Minot, N. Dak.	Jan. 27
Feb. 1.	Meridian, Miss.	Jan. 27
Feb. 1.	Batesville, Miss.	Jan. 27
Feb. 1.	St. Paul, Minn.	Jan. 27
Feb. 1.	Marshall, Ia.	Jan. 27
Feb. 1.	Crown Point, Ind.	Jan. 27
Feb. 2.	Kingman, Kan.	Jan. 20
Feb. 3.	Corydon, Ind.	Jan. 27
Feb. 5.	Toledo, O.	Jan. 27
Feb. 5.	Cincinnati, O.	Jan. 20
Feb. 6.	Mena, Ark.	Jan. 20
Feb. 6.	Cuero, Texas	Jan. 27
Feb. 9.	Lawton, Okla.	Jan. 27
Feb. 10.	Fort Des Moines, Ia.	Jan. 27
Feb. 12.	Grand Forks, N. Dak.	Jan. 27
Feb. 15.	Norwalk, O.	Jan. 27
Feb. 15.	Lisbon, O.	Jan. 27
Feb. 16.	Waseca, Minn.	Jan. 27
Feb. 20.	Cleveland, O.	Jan. 27
Mar. 4.	Paris, Ark.	Jan. 13

Buildings.

Jan. 27.	Fort Leavenworth, Kan.	Jan. 6
Jan. 27.	Pittsburg, Pa.	Jan. 20
Jan. 27.	Baltimore, Md.	Jan. 20
Jan. 28.	Ames, Ia.	Jan. 6
Jan. 29.	Vancouver Barracks, Wash.	Jan. 20
Jan. 29.	Pittsburg, Pa.	Jan. 27
Jan. 29.	Pittsburg, Pa.	Jan. 27
Feb. 1.	Regina, Sask.	Jan. 20
Feb. 1.	Claremore, Okla.	Jan. 6
Feb. 1.	Parkersburg, W. Va.	Jan. 13
Feb. 1.	Midland, Texas	Jan. 13
Feb. 1.	Newcastle, Ind.	Jan. 13
Feb. 1.	Los Angeles, Cal.	Jan. 13
Feb. 1.	Columbus, O.	Jan. 20
Feb. 1.	Cleveland, O.	Jan. 20
Feb. 1.	Industry, N. Y.	Jan. 27
Feb. 3.	Binghamton, N. Y.	Jan. 27
Feb. 3.	Albany, N. Y.	Jan. 27
Feb. 3.	Kansas City, Mo.	Jan. 27
Feb. 4.	San Antonio, Texas	Dec. 30
Feb. 4.	West Durham, N. C.	Jan. 20
Feb. 5.	Danville, Va.	Jan. 27
Feb. 6.	Reading, O.	Jan. 27
Feb. 6.	Welch, D. Va.	Jan. 20
Feb. 8.	Columbus Barracks, O.	Jan. 20
Feb. 9.	Fort Myer, Va.	Jan. 20
Feb. 9.	Athens, O.	Jan. 20
Feb. 10.	National Soldiers' Home, Va.	Jan. 20
Feb. 10.	Stanford, Ky.	Jan. 20
Feb. 11.	Dulce, N. Mex.	Jan. 13
Feb. 11.	Clarinda, Ia.	Jan. 13
Feb. 11.	Madisonville; Tenn.	Jan. 20
Feb. 13.	Watkins, N. Y.	Jan. 27
Feb. 15.	Fort Monroe, Va.	Jan. 27
Feb. 15.	Grand Rapids, Mich.	Jan. 13
Feb. 15.	Shenandoah, Ia.	Jan. 13
Feb. 15.	Fort Dupont, Del.	Jan. 20
Feb. 15.	Grand Rapids, Mich.	Jan. 20
Feb. 16.	Youngstown, O.	Jan. 27
Feb. 16.	Washington, D. C.	Jan. 20
Feb. 17.	Redfield, S. D.	Jan. 20
Feb. 17.	Salisbury, N. C.	Jan. 20
Feb. 18.	Greenville, Miss.	Jan. 20
Feb. 18.	Newton, Ia.	Jan. 27
Feb. 20.	Bar Harbor, Me.	Jan. 20
Feb. 23.	Fort Riley, Kan.	Jan. 27
Feb. 24.	Sigourney, Ia.	Jan. 27
Feb. 27.	La Salle, Ill.	Jan. 13
Mar. 1.	Omaha, Neb.	Jan 6
Mar. 3.	Augusta, Ga.	Jan. 27

Roads and Streets.

Jan. 28	Galveston, Texas	Jan 27
Jan 30	Cleveland, O	Jan 13
Feb 1.	Olympia, Wash	Dec 23
Feb 1	Olympia, Wash.	Jan. 20
Feb. 1	Moorhead, Minn	Jan 20
Feb. 1	Greenfield, Ind.	Jan 20
Feb. 1.	Wabash, Ind	Jan. 20
Feb. 1.	Vevay, Ind	Jan 20
Feb. 1.	Fowler, Ind	Jan. 20
Feb. 1	Delphi, Ind	Jan 20
Feb. 1.	Decatur, Ind.	Jan. 20
Feb. 1.	Columbus, Ind.	Jan. 20
Feb. 1.	Shenandoah, Ia	Jan 27
Feb. 1.	Washington, Ind	Jan. 27
Feb. 1	Williamsport, Ind	Jan 27
Feb. 1.	Lebanon, Ind	Jan. 27
Feb 1.	Crown Point, Ind.	Jan 27
Feb. 2.	Crawfordsville, Ind.	Jan 20
Feb. 2.	Vincennes, Ind	Jan. 20
Feb. 2.	Valparaiso, Ind.	Jan 20
Feb. 2.	Paoli, Ind	Jan. 20
Feb. 3.	Cleveland, O.	Jan. 6
Feb. 3.	Bluffton, Ind.	Jan. 13
Feb. 3.	Kokomo, Ind.	Jan. 20
Feb. 3.	Brooklyn, N Y	Jan. 27
Feb. 3.	Muncie, Ind.	Jan. 27
Feb. 3.	Logansport, Ind.	Jan. 27
Feb. 3.	Bloomington, Ind.	Jan. 27
Feb. 4.	Frankfort, Ind.	Jan. 20
Feb. 4.	Frankfort, Ind.	Jan. 20
Feb. 4.	Rockville, Ind.	Jan. 27
Feb. 4.	Laporte, Ind.	Jan. 27
Feb. 4.	Blufftown, Ind.	Jan. 27
Feb. 4.	Bluffton, Ind	Jan. 27
Feb. 5.	Lebanon, Ind.	Jan. 13
Feb. 5.	Anderson, Ind.	Jan 13
Feb. 5.	Cincinnati, O.	Jan. 20
Feb. 5.	St. Louis, Mo.	Jan. 27
Feb. 5.	Tipton, Ind.	Jan. 27
Feb. 6.	Terre Haute, Ind.	Jan. 27
Feb. 8.	Indianola, Ia.	Jan. 27
Feb. 8.	Franklin, Ind.	Jan. 27
Feb. 11.	Appleton, Wis.	Dec. 30
Feb. 15.	Whipple Barracks, Ariz.	Jan. 27
Feb. 18.	Spencer, Ind.	Jan. 27
Feb. 18.	Spencer, Ind.	Jan. 20
Mar. 2.	Bloomington, Ind.	Jan. 27

Sewers.

Jan. 27.	Brooklyn, N. Y.	Jan. 20
Jan. 29.	Toledo, O.	Jan. 27
Jan. 29.	Oswego, N. Y.	Jan. 27
Jan. 30.	Keokuk, Ia.	Jan. 27
Jan. 30.	Belleville, Ill.	Jan. 27
Feb. 1.	Moorhead, Minn.	Jan. 20
Feb. 1.	Lincoln, Ill.	Jan. 27
Feb. 1.	Vicksburg, Miss.	Jan. 27
Feb. 1.	Decatur, Ill.	Jan. 27
Feb. 2.	Toronto, Ont.	Jan. 27
Feb. 2.	Marion, Kan.	Jan. 27
Feb. 2.	Ottawa, Ill.	Jan. 27
Feb. 3.	Brooklyn, N. Y.	Jan. 27
Feb. 5.	Louisville, Ky.	Jan. 27
Feb. 8.	College Hill, O.	Jan. 20
Feb. 10.	Detroit, Minn.	Jan. 27
Feb. 11.	Brantford, Ont.	Jan. 27
Feb. 16.	Ashtabula, O.	Jan. 27
Feb. 17.	East St. Louis, Ill.	Jan. 20

Water Supply.

Jan. 29.	Carlyle, Ill.	Jan. 13
Feb. 1.	Denison, Ia.	Jan. 6
Feb. 1.	Avonmore, Pa.	Jan. 20
Feb. 1.	Gillette, Wyo.	Jan. 27
Feb. 2.	Hugo, Okla.	Jan. 20
Feb. 2.	Scranton, Miss.	Jan. 27
Feb. 3.	Baltimore, Md.	Jan. 27
Feb. 4.	Minot, N. Dak.	Jan. 20
Feb. 5.	Key West, Fla.	Jan. 6
Feb. 5.	Key West, Fla.	Jan. 13
Feb. 15.	New Ulm, Minn.	Jan. 20
Feb. 15.	Sebree, Ky.	Jan. 20
Mar. 15.	Wichita, Kan.	Jan. 20

Miscellaneous.

Jan. 27	Fort Wayne, Ind.	Steel Erecting,	Jan 27
Feb. 1.	Albany, N. Y.,	Steel Dirt Removal,	Jan. 27
Feb. 1.	Philadelphia, Pa.,	Borings,	Jan. 27
Feb. 3.	Baltimore, Md.	Lighting System, etc.,	Jan. 27
Feb. 5.	St. Louis, Mo.,	Street Lighting,	Jan. 13
Feb. 6	Boston, Mass.,	Wreck Removal,	Jan. 20
Feb. 8	Prescott, Ariz.,	Fence,	Jan 13
Feb. 11	Mobile, Ala.,	Pontoons,	Jan 20
Feb. 12.	Milwaukee, Wis.,	Concrete Caissons,	Jan. 20
Feb. 13.	Hawaii,	Dry Dock,	Dec. 9
Feb. 16	Frankfort, Mich.,	Pier Work,	Jan 27

Excavation, Earth and Rock.

Jan 27	Crookston, Minn.,	Ditch Work	Jan 6
Jan 30	Sterling, Ill.,	Ditch Work	Jan 13
Jan 30	Velasco, Texas,	Drainage Work	Jan [illegible]
Feb 1	Sioux City, Ia.,	Ditch Work,	Jan 6
Feb 1	Fayette, Mi[illegible]	Drainage Work	Jan 27
Feb 1	Philadelphia, Pa.	Dredging,	Jan 27
Feb 5	Girard, Ill.,	Tile Ditch,	Jan 20
Feb 6	Edinburg, Ill.,	Tile Drain,	Jan 27
Feb 6	Delphi, Ind.,	Ditch	Jan 2[illegible]
Feb. 6	Atkinson, Ill.,	Ditches,	Jan. 20
Feb. 10.	Logan, Ia.,	Ditch Work,	Jan 6
Feb 18.	Fowler, Ind.,	Ditch Work,	Jan 27

Materials, Machines, Supplies, Etc.

Feb. —	Detroit, Mich.,	Road Rollers,	Jan. 27
Jan. 27.	Pittsburg, Pa.,	Supplies,	Jan. 20
Jan. 28	Kingston, Ont.,	Cement, Sewer Pipe,	Jan. 27
Jan. 29.	Pittsburg, Pa.,	Crane,	Jan 27
Jan. 29.	Ottawa, Ont.,	Cement,	Jan. 6
Jan. 30.	Mare Island, Cal.,	Elevator,	Jan 13
Feb. 1.	Leavenworth, Kan.,	Pipe, Etc.,	Jan. 13
Feb. 1.	Jamestown, N. D.,	Water Meters,	Jan. 20
Feb. 1.	Washington, D. C.,	Motors, Blocks, Etc.,	Jan. 20
Feb. 1.	Anadarko, Okla.,	Pumps, Pipes, Etc.,	Jan. 27
Feb. 2.	Richland Center, Wis.,	Pump,	Jan. 6
Feb. 2.	Kenosha, Wis.,	Pumping Engine,	Jan. 13
Feb. 3.	Saskatchewan, Sask.,	Boilers,	Jan. 27
Feb. 3.	Buffalo, N. Y.,	Engine Dynamo,	Jan. 27
Feb. 3.	Chicago, Ill.,	Transformers, Watermeters,	Jan. 27
Feb. 3.	Baltimore, Md.,	Tile,	Jan. 27
Feb. 5.	Key West, Fla.,	Condenser, Filter, Etc.,	Jan. 6
Feb. 5.	Banff, Alberta,	Sewer Pipe,	Jan. 13
Feb. 6.	Lorain, O.,	Pump,	Jan. 27
Feb. 8.	Washington, D. C.,	Drills, Valves, Etc.,	Jan. 20
Feb. 9	New York, N. Y.,	Broken Stone,	Jan 27
Feb. 10.	Phoenix, Ariz.,	Pumping Engine,	Jan. 27
Feb. 15.	Superior Entry, Wis.,	Piles,	Jan. 20
Feb. 15.	Savannah, Ga.,	Paving Blocks,	Jan 27
Feb. 15.	Washington, D. C.,	Track Supplies,	Jan 27
Feb. 17.	Milwaukee, Wis.,	Gas Producer and Gas Engine, Electric Light Plant	Jan 13
Feb. 22	Winnipeg, Man.,	Pump, Motor,	Dec. 9
Mar. 1.	Lethbridge, Alberta,	Electrical Mach., Etc.,	Jan 27

BIDS ASKED

Bridges.

Bids are asked on following work, the notes being arranged alphabetically by states:

Fort Des Moines, Ia.—Until 3 p. m., Feb. 10, by Constructing Quartermaster, at Fort Des Moines, for constructing steel highway bridge at target range. Official advertisement will be found elsewhere in this issue.

Marshalltown, Ia.—Until Feb. 1, by County Auditor, for constructing concrete culvert on 13th St., to cost about $2,500.

Corydon, Ind.—Until 2 p. m., Feb. 3, by Wm. Taylor, County Auditor, for the construction of a bridge over Buck Creek.

Crown Point, Ind.—Until noon, Feb. 1, by the County Commissioners, for constructing a reinforced-concrete bridge over Calumet River at Broadway, Gary. The bridge is to consist of three 66-ft. arches with retaining walls, etc. W. F. Bridge, Engineer, Hammond, Ind.

St. Paul, Minn.—Until Feb. 1, by George T. Redington, Secretary Park Commissioners, for bids, including plans and specifications, for constructing reinforced concrete bridges over the Ravine on Riverside Blvd., the bridges to be 105 ft. 8 ins. long, 28-ft. roadway and two 6-ft. walks.

Waseca, Minn.—Until Feb. 16, according to reports, by County Auditor, for constructing several bridges.

Batesville, Miss.—Until Feb. 1, by County Supervisors, R. W. Draper, Clerk, for the building of iron bridges over Coldwater River near Askew, Miss. and over Orr Creek about 3 miles east of Sardis, Miss.

Meridian, Miss.—Until Feb. 1, by W. R. Pistole, Chancery Clerk, for constructing wooden bridge over Okitbeba Creek on Land Line Road.

Grand Forks, N. Dak.—Until 10 a. m., Feb. 12, by Hans Anderson, County Auditor, for building any or all steel and wooden bridges that may be ordered built by County during 1909.

Minot, N. Dak.—Until Feb. 1, by Commissioners of Ward County, for constructing Belyea Ave. bridge in Minot. County Surveyor Thomas has prepared three plans, one calling for a steel structure and two for reinforced concrete. The steel bridge will cost from $5,000 to $6,000 and the reinforced concrete bridge about $1,000 more.

Cleveland, O.—Until 11 a. m., Feb. 20, by County Commissioners, Wm. F. Black, Clerk, for constructing two culverts on Canal Road in Newburg Township.

Lisbon, O.—Until Feb. 15, by County Auditor, for abutments for a bridge located near the pumping station at East Palestine. At the same time bids will be received for the erection of an iron skew bridge at the above location, 50 ft. in length with a 14-ft. clear roadway and a 6-ft. sidewalk on one side.

Norwalk, O.—Until 11 a. m., Feb. 15, by County Auditor, for building a sandstone abutment at the west end of the Green Creek bridge on the Maumee Pike, also for the erection of steel joists and putting in a kreodone block floor system on the same bridge.

Toledo, O.—Until Feb. 3, by Board Public Service, Reynold Voit, Secretary, for repairs to the bridge over the Maumee River at Cherry St.

Lawton, Okla.—Until Feb. 9, by County Commissioners of Comanche County, for constructing two steel bridges—a 75-ft. span and a 32-ft. span.

Cuero, Tex.—Until Feb. 6, by Rudolph Kleberg, Jr., County Judge, for constructing bridge over Guadalupe River, near Hochheim, Tex.

La Prairie, Que.—Until 6 p. m., Jan. 29, by F. C. Larose, Secretary-Treasurer, for constructing iron bridge over River St. Jacques.

Buildings.

Bids are asked on following work, the notes being arranged alphabetically by states:

Augusta, Ga.—Until 3 p. m., Mar. 3, by James Knox Taylor, Supervising Architect, Washington, D. C., for the construction complete (except elevator) of an extension to the U. S. Postoffice at Augusta.

Newton, Ia.—Until 2 p. m., Feb. 18, by Frank Sellman, County Auditor, for the erection and completion of a 3-story courthouse. Proudfoot & Bird, Architects, 625 Flynn Bldg., Des Moines, Ia.

Sigourney, Ia.—Until noon, Feb. 24, by A. W. Lynn, County Auditor, for the general construction of a court house. Wetherell & Gage, Architects, 202 Youngman Bldg., Des Moines, Ia.

Fort Riley, Kan.—Until 10 a. m., Feb. 23, by Capt. W. N. Whitman, Constructing Q. M., for constructing two hay sheds.

Kansas City, Mo.—Until Feb. 3, by County Clerk, for the construction of a power and laundry building and smokestack at the Jackson County Home for the Aged and Infirm, at the County Farm near Little Blue. Smith & Rea, Architects, Dwight Bldg., Kansas City, Mo.

Albany, N. Y.—Until noon, Feb. 3, by State Board of Armory Commissioners, F. A. McNeely, Secretary Capitol, Albany, for repairs to armory at Albany.

Binghamton, N. Y.—Until 3 p. m., Feb. 3, by State Commission in Lunacy, T. E. McGarr, Secretary, Capitol, Albany, N. Y., for construction of vegetable store house and for farmer's cottage, including heating, plumbing and electric work, at the Binghamton State Hospital, Binghamton. Franklin B. Ware, State Architect, Albany, N. Y.

Industry, N. Y.—Until 7 p. m., Feb. 1, by Miss Lura E. Aldridge, President of the Board of Managers, New York State Agricultural and Industrial School, Industry, for construction complete, including heating, plumbing and electric work for addition to industrial building, hospital for contagious diseases, four cottages for boys and five cottages for employes at the New York State Agricultural and Industrial School. Franklin B. Ware, State Architect, Albany, N. Y.

Watkins, N. Y.—Until 2 p. m., Feb. 13, by Charles M. Woodward, Secretary Committee, Watkins, for construction complete, including plumbing, for a waiting pavilion at Watkins Glen, Watkins.

Reading, O.—Until noon, Feb. 6, by Louis M. Comer, Secretary of Committee, 1204 Market St., for the erection of Eagles' Hall, to be built according to plans and specifications on file in the office of Garber & Woodward, Architects, 907 Andrews Bldg., Cincinnati, O., or at office of Louis Uehlin, 309 Benson St., Reading, O.

Youngstown, O.—Until 11 a. m., Feb. 16, County Building Commission, W. B. Jones, Secretary, at office of County Auditor, for the construction of the Mahoning County jail at Youngstown. The different proposals are for the construction of a complete building in accordance with plans and specifications for the same, which will be on file at the office of the County Auditor on and after Feb. 2. Owsley, Boucherle & Co., Architects, Maloney Blk., Youngstown, O.

Pittsburg, Pa.—Until 10 a. m., Jan. 29, by A. B. Shepherd, Director Public Works, for construction of a storage building at the Brilliant pumping station and for furnishing and placing crane in the building. Bond for $10,000 required for the construction of the building.

Pittsburg, Pa.—Until 10 a. m., Jan. 29, by A. B. Shepherd, Director Public Works, for the following work: Erection and completion of low pressure steam heating and ventilating apparatus for the recreation building at Washington Park; erection and completion of low pressure gravity steam heating apparatus in swimming pool building in Lawrence Park.

Danville, Va.—Until Feb. 5, by Charles M. Robinson, for erection of a brick and concrete school house at this city.

Fort Monroe, Va.—Until 10 a. m., Feb. 15, by Capt. Ernest R. Tilton, Constructing Q. M., for construction, heating, plumbing, electrical wiring and fixtures for two sets of Field Officers' Quarters at Fort Monroe.

Roads and Streets.

Bids are asked on following work, the notes being arranged alphabetically by states:

Whipple Barracks, Ariz.—Until 3:30 p. m., Feb. 15, by Lieut. K. P. Williams, Constructing Q. M., Prescott, Ariz., for construction of concrete walks around and from 11 sets of officers' quarters to proposed main walk at Whipple Barracks.

Bluffton, Ind.—Until 10 a. m., Feb. 4, by O. D. Garrett, County Auditor, for the construction of the following gravel and macadamized roads: One between Jefferson and Lancaster Townships, 10,596 ft.; two in Jefferson Township, 10,397 and 10,598 ft.; one in Union Township, 5,250 ft.; two in city of Bluffton, 4,854 and 3,752 ft.

Bluffton, Ind.—Until 10 a. m., Feb. 4, by O. D. Garrett, County Auditor, for the construction of two stone roads in Jefferson Township, two in Harrison Township and one in Jefferson-Lancaster Township. Also for the construction of a gravel road in Union Township.

Bloomington, Ind.—Until 2 p. m., Mar. 2, by P. M. Cook, County Auditor, for constructing gravel and macadamized road in Wright Township; also for similar road in Stockton and Wright Townships.

Bloomington, Ind.—Until 2 p. m., Feb. 3, by Horace Blakely, County Auditor, for constructing two pike roads in Bloomington Township.

Crown Point, Ind.—Until noon, Feb. 1, by Charles A. Johnson, County Auditor, for constructing three gravel roads in North Township.

Franklin, Ind.—Until 1:30 p. m., Feb. 8, by W. B. Jennings, County Auditor, for constructing gravel road in Union Township.

Laporte, Ind.—Until 10 a. m., Feb. 4, by Chas. H. Miller, County Auditor, for constructing two macadam roads in Center Township.

Lebanon, Ind.—Until 1 p. m., Feb. 1, by B. F. Herdrich, County Auditor, for the construction of a gravel road in Clinton Township, 10,730 ft. long.

Logansport, Ind.—Until noon, Feb. 3, by Geo. W. Cann, County Auditor, for constructing the following roads: Stone road on line dividing Jackson and Tipton Townships; macadamized road in Boone Township; stone road on line dividing Washington and Deer Creek Townships, and macadamized road diiding Jackson, Tipton and Deer Creek Townships.

Logansport, Ind.—Until noon, Feb. 3, by George W. Cann, County Auditor, for constructing following roads: Stone road on line dividing Jackson and Tipton Townships; macadamized road in Boone Township; stone road on line dividing Washington and Deer Creek Townships, and macadamized road dividing Jackson, Tipton and Deer Creek Townships.

Muncie, Ind.—Until 10 a. m., Feb. 3, by J. E. Davis, County Auditor, for improvement of two highways in Delaware Township, by grading, draining and paving with crushed stone; also for improvement of a public highway in Center Township, by grading, draining and paving with brick.

Rockville, Ind.—Until 1:30 p. m., Feb. 4, by H. A. Henderson, County Auditor, for the construction of a gravel road in Union Township.

Spencer, Ind.—Until noon, Feb. 18, by Geo. W. Edwards, County Auditor, for constructing gravel road on line between Clay and Owen Counties; also for constructing the following gravel and macadamized roads: one in Franklin Township, 9,307 ft.; one in Jackson Township, 11,062 ft., and one in Wayne Township, 13,222 ft.

Terre Haute, Ind.—Until 11 a. m., Feb. 6, by N. G. Wallace, County Auditor, for the improvement by grading, graveling and paving the following roads: one in Prairieton Township, two in Honey Creek Township and one in Fayette Township.

Tipton, Ind.—Until 10 a. m., Feb. 5, by J. F. Barlow, County Auditor, for constructing three gravel roads.

Williamsport, Ind.—Until 1 p. m., Feb. 1, by Robert L. Winks, County Auditor, for constructing gravel road in Liberty Township.

Washington, Ind.—Until 2 p. m., Feb. 1, by Thomas Nugent, County Auditor, for constructing gravel road in Washington Township.

Indianola, Ia.—Until 7 p. m., Feb. 8, by Arthur Lee, City Clerk, for constructing about 15,300 sq. yds. of 3-in. creosoted wood block paving on a 5-in. concrete foundation and about 7,884 lin. ft. of 6-in. x 20-in. concrete curb, and 450 yds. of extra grading.

Shenandoah, Ia.—Until Feb. 1, by City Clerk, for paving Maple St. and north end of Elm St. with creosoted blocks, at an estimated cost of $2.65 per sq. yd.

St. Louis, Mo.—Until Feb. 5, by Board Public Improvements, W. B. Dayton, Secretary, for paving portions of a number of streets.

Brooklyn, N. Y.—Until 11 a. m., Feb. 3, by Bird S. Coler, Borough President, for improvement of portions of several streets by regulating and paving with asphalt, and by laying sidewalks.

Galveston, Tex.—Until noon, Jan. 28, by City Commissioners, A. T. Dickey, City Engineer, for constructing 4,235 sq. yds. of brick pavement and 1,158 lin. ft. of concrete curb on 23rd St.

Sewers.

Bids are asked on following work, the notes being arranged alphabetically by states:

Keokuk, Ia.—Until noon, July 30, by J. Ross Robertson, City Engineer, for construction of 1,050 lin. ft. of 8-in. sewer.

Belleville, Ill.—Until Jan. 30, by Board Local Improvements, for constructing sewers in Missouri Ave., State St., and Virginia Ave.

Decatur, Ill.—Until 2 p. m., Feb. 1, by Board Local Improvements, A. B. Alexander, Engineer, for constructing 18-in., 15-in. and 12-in. vitrified tile sewer.

Lincoln, Ill.—Until 10 a. m., Feb. 1, according to reports by City Clerk, for constructing Hamilton St. sewer.

Ottawa, Ill.—Until 7 p. m., Feb. 2, by Board Local Improvements, W. H. Irwin, Secretary, for constructing sewer in Fulton St., the work including: 760 ft. 12-in., 608 ft. 10-in. and 286 ft. 8-in. sewer; 416 ft. 8-in. inlet connection; 5 brick man-holes, total depth 40 ft.; constructing foundation and placing inlets, $60; 3,500 lbs. of iron castings; 90 lbs. of wrought iron steps; 840 cu. yds. of rock excavation.

Marion, Kan.—Until Feb. 2, by City Clerk, for constructing about 2¼ miles of main and lateral sewers in Sewer District No. 3.

Louisville, Ky.—Until noon, Feb. 5, by the Commissioners of Sewerage, J. B. F. Breed, Chief Engineer, for the construction of sewers known as Walnut St. Contracts No. 21

and No 22, Clay St Sewer Contract No 23, and St Xavier St. Sewer, Contract No 24. The work will consist of about 5,460 ft of concrete and pipe sewers of sizes between 18 in and 30 in. diameter and including 315 cu yds. of concrete. The depth of these sewers is from 6 to 10 ft.

Detroit, Minn.—Until 7 p. m., Feb 10, by Chas G Sturtevant, City Clerk, for labor and material for constructing a sewer system, to include two sewer lifts, septic tank and storm water sewer. Loweth & Wolff, Engineers Old First National Bank Bldg., St. Paul, Minn.

Vicksburg, Miss.—Until Feb. 1, by Mayor J J Hayes, for constructing storm sewer in Clay St.

Brooklyn, N. Y.—Until 11 a m., Feb. 3, by Bird S. Coler, Borough President, for constructing several sewers.

Oswego, N. Y.—Until 2 p. m., Jan. 29, by John Smith, Commissioner of Public Works, for constructing 12-in. tile sewer in Mitchell St.

Ashtabula, O.—Until noon, Feb 16, by Board Public Service, A. J. Richardson Clerk, for constructing 1,372 lin. ft. of 1 ft 10 in. x 2 ft. 9 in. concrete sewer, 3,020 lin. ft. of 1 ft. 8 in. x 2 ft. 6 in. concrete sewer, 774 lin. ft. of 20-in. sewer, 2,154 lin. ft of 15-in. sewer and 1,790 lin ft of 12-in. sewer. Official advertisement will be found elsewhere in this issue.

Toledo, O.—Until noon, Jan. 29, by Board Public Service, Reynold Volt, Secretary, for labor and material for constructing a local sewer.

Toronto, Ont.—Until noon, Feb. 2, by Mayor Joseph Oliver, Chairman of the Board of Control, City Hall, for the construction of Sec. No. 3 of the high level intercepting sewer. Tenders may be alternative for brick and concrete as called for in the revised specifications. The following is an approximate statement of the work required to be done: 1,972 lin. ft. of 7 ft. 6 in., 2,419 lin. ft. of 7 ft. 9 in., 1,556 lin. ft. of 8 ft., and 439 lin. ft. of 8 ft. 6 in., together with manholes, connections, etc.

Brantford, Ont.—Until noon, Feb. 11, by Chairman Board of Works, care City Clerk, for the furnishing and laying of about 2,250 ft of 12-in. extra strength sewer pipe and 635 ft. of 12-in. cast iron pipe, together with 11 manholes. Greatest cut, 32 ft. Average cut, 17½ ft. T. Harry Jones, City Engineer.

Water Supply.

Bids are asked on following work, the notes being arranged alphabetically by states:

Baltimore, Md.—Until 11 a. m., Feb. 3, by the Sewerage Commission, Harry W. Rodgers, Secretary, 904 American Bldg., for Sanitary Contract No. 37—construction of water tanks and tower at the sewage disposal works on Back River.

Scranton, Miss.—Until Feb. 2, by M. M. Watkins, City Clerk, for erecting 75,000-gal. steel tank with spherical bottom, on steel tower 100 ft. height to balcony. For specifications address Walter G. Kirkpatrick, Engineer, Jackson, Miss.

Gillette, Wyo.—Bids are reported asked by City Clerk until Feb. 1, for constructing water works for this city.

Miscellaneous.

Bids are asked on following work, the notes being arranged alphabetically by states:

Fort Wayne, Ind.—Steel Erecting—Until noon, Jan. 27, by William F. Stillwell, General Contractor, Lafayette, Ind., for erecting steel for the Shoaff (9-story) Office Building, located in Ft. Wayne. The steel will be delivered on the ground with all work done on the same that is usually done away from the building. The contractor has all hoisting machinery he deems necessary for the erection of this steel which the sub-contractor will be allowed to use upon reasonable terms.

Baltimore, Md.—Lighting System, Etc.—Until 11 a. m., Feb. 3, by Park Board, Wm S. Manning, General Superintendent, Druid Hill Park, for work to be done at Federal Hill Park and for the installation of an Underground Electric Lighting System at Patterson Park. The work contemplated is: (1) The under-drainage of slopes on Hughes and Covington Sts. sides of Federal Hill Park and the repairing of a retaining wall on Battery Ave., Federal Hill Park. (2) The installation of an electric lighting system around the swimming pool, men and women's gymnasium, running track, and along the mall in Patterson Park.

Frankfort, Mich.—Pier Work.—Until 3 p. m., Feb. 16, by Col M B Adams, U S Engr., 57 Park St., Grand Rapids, Mich, for repair of south pier at Frankfort.

Albany, N. Y.—Street Dirt Removal, Etc Until 3 p. m., Feb. 1, by Board of Contract and Supply, Isidore Wachsman, Secretary, for (1) removal of street dirt, bond for $10,000 required with bid, and (2) removal of dead animals, bond for $100 required with bid.

Philadelphia, Pa.—Borings—Until noon, Feb 1, by J. C. Grady, Director Department of Wharves, Docks and Ferries, for borings necessary to show the nature of the Delaware River bottom, on the site of the proposed Dock St. and Vine St piers, between the bulkhead line and Port Warden's line.

Excavation, Earth and Rock.

Bids are asked on following work, the notes being arranged alphabetically by states:

Edinburg, Ill.—Tile Drain—Until 11 a m., Feb. 6, by Commissioners of District No 2, care O. L. Whitmer, Town Clerk, Edinburg, for furnishing, hauling, laying, etc., 10,830 ft., 7-in. to 22-in. tile. J. W. Dappert, Engineer, Taylorville, Ill.

Delphi, Ind.—Ditch.—Until 1 p. m., Feb. 6, by J. D. Zartman, Drainage Commissioner of Carroll County, at the law office of J. O. Olear, Delphi, for the construction of the Robertson ditch.

Fowler, Ind.—Ditch Work.—Until 1 p. m., Feb. 18, by Chester B. Whicker, Superintendent of Construction, at office of County Surveyor, for constructing W. B. Curtis joint ditch in Round Grove Township. Work consists of 7,100 ft. of tile and 31,300 ft. of dredge work. Official advertisement will be found elsewhere in this issue.

Fayette, Miss.—Drainage Work.—Until Feb. 1, by Commissioners of Gum Ridge Drainage District, for construction of system of canals and levees for the district; work includes about 140,000 cu. yds. C. H. Jenks, Engineer, Fayette, Miss.

Philadelphia, Pa.—Dredging.—Until noon, Feb. 1, by J. C. Grady, Director Department of Wharves, Docks and Ferries, dredging docks and bulkheads in the Delaware and Schuylkill Rivers, including shoals adjacent or near any pier, during the year 1909.

Materials, Machines, Supplies, Etc.

Bids are asked on following work, the notes being arranged alphabetically by states:

Phoenix, Ariz.—Pumping Engine.—Until 4 p. m., Feb. 10, by Robt. A. Craig, Superintendent of Water Works, for a 3,000,000-gallon pumping engine.

Washington, D. C.—Track Supplies.—Until 10:30 a. m., Feb. 15, by Capt. F. C. Boggs, General Purchasing Officer, Isthmian Canal Commission, for furnishing, under Circular 491, steel rails, angle bars, tie plates, frogs, switch points, switch stands, rail braces, spikes, track bolts, etc.

Savannah, Ga.—Paving Blocks.—Until Feb. 15, by Harry Willink, Director Public Works, for furnishing city with 5,000 sq. yds. of granite paving blocks, f. o. b. Savannah.

Chicago, Ill.—Transformers, Wattmeters. Until noon, Feb. 3, by Trustees Sanitary District of Chicago, I. J. Bryan, Clerk, American Trust Bldg., for furnishing and installing (1) transformers, and (2) alternating current wattmeters.

Baltimore, Md.—Tile—Until Feb. 2 by Board of Awards, J. Barry Mahool, President, for furnishing buff color brick or asphalt tile and block for projected improvements for Park System Approximately 100,000 brick or asphalt tile and block of equivalent area will be purchased J Harry Gross, Park Engineer, Druid Hill Park

Detroit, Mich.—Road Rollers—Board of County Road Commissioners will open bids early in February for the purchase of two steam rollers to be used in road construction

Buffalo, N. Y.—Engine, Dynamo, Etc—Until 3 p. m., Feb. 3, by State Commission in Lunacy, T E McGarr Secretary, Albany, N Y, for engine and dynamo, switchboard, new feed water heater and changes to exhaust mains at the Buffalo State Hospital Buffalo Franklin B Ware, State Architect, Albany, N Y

New York, N. Y.—Broken Stone—Until noon, Feb 9 by George Cromwell President Richmond Borough, for furnishing and delivering 25,000 tons of broken stone and screenings.

Lorain, O.—Pump.—Until noon, Feb 6 by Board Public Service, A. W. Thomas, Clerk, for furnishing deep well pump of a capacity of 10,000 gallons per hour

Anadarko, Okla.—Pumps, Pipe, Etc—Until Feb. 1, by the Mayor, for the purchase by said city of two triplex pumps, two return tubular boilers, cast-iron water pipe, hydrants and valves, and sewer pipe and fittings, also for flush tanks and manhole covers. Specifications from O'Neil Engineering Co., Dallas, Tex.

Pittsburg, Pa.—Crane.—Until 10 a m., Jan. 29, by A. B. Shepherd, Director Public Works, for furnishing and placing crane in storage building at the Brilliant pumping station. See also under Bids Asked Buildings.

Saskatchewan, Sask.—Boilers—Until 6 p. m., Feb. 3, by J. H. Trusdale, City Clerk, for 500 H P. boilers in two or three units.

Kingston, Ont.—Cement, Sewer Pipe.—Until noon, Jan 28, by H B R. Craig, City Engineer, for furnishing 5,000 bbls of Portland cement and for furnishing sewer pipes

Lethbridge, Alberta.—Electrical Machinery, Etc—Until Mar. 1, by George W. Robinson, Secretary-Treasurer, City of Lethbridge, for a municipal power plant Bids are wanted on the following: A, boilers and accessories, B, economizer, C, feed pumps, D, mechanical draft, E, pipe work and valves; F, steam turbine generator, G, steam engine generator, H, re-erection of steam engines; I, condensing sets, J, crane, K, switchboards, etc.; L, motor generators and transformers; M, building steel work, etc. Smith, Kerry & Chance, Engineers, Toronto, Ont.

CONTRACTS LET.

The following contracts have been let recently:

Augusta, Ga.—Bridge.—Roanoke Bridge Co., Roanoke, Va, at $27,596, for constructing bridge over Savannah River at Center St.

Gainesville, Ga.—Post Office—Wilmarth Building Co., New York City, for constructing U. S. Post Office building in this city

Gadsden, Ala.—Sidewalks.—Chas. Duncan, at 85 cts. per sq. yd, for 5,000 sq. yds. of sidewalk paving.

Boulder, Colo.—Concrete Dam—MacArthur Bros. Co., 11 Pine St., New York, for constructing Barker Meadow Dam at Boulder. Dam will be built of cyclopedian concrete masonry and will contain about 1[illegible],000 cu. yds. of concrete.

Denver, Colo.—Irrigation System—Parker-Washington Construction Co, 4500 Duncan Ave, St. Louis, Mo, has contract for constructing irrigation system for the Henrylyn Irrigation District. About $3,000,000 will be expended, it is said. The canals will be 90 miles long, and a series of reservoirs will be built along the course A 15,000-ft tunnel will be bored

Chicago, Ill.—Bridge Work—George W Jackson Co Inc, Chicago, at $32,31[illegible] for constructing superstructures for Mayfair cut-off bridge and Milwaukee Division bridge at the crossings of the C & N W Ry or the North Shore Channel The weight of the superstructure of the Mayfair cutoff bridge is 750,000 lbs and the weight of the Milwaukee Division bridge is [illegible]92,000 lbs The bids received by the Trustees of the Sanitary District, Chicago C R Dart Bridge Engineer were as follows (1) standing for lump bid for superstructure of Mayfair cutoff bridge, (2) for lump bid for superstructure of Milwaukee Division bridge, (3) for extra structural steel in cents per pound, (4) for extra steel castings in cents per pound, (5) for extra iron castings in cents per pound, and (6) for the total bid

	(1)	(2)	(3)	(4)	(5)	(6)
Geo. W Jackson, Inc, Chicago Ill	$ [illegible]	$10,464 00	4½	10	3½	$[illegible]
The Toledo-Massillon Bridge Co Toledo O.	[illegible]	11,[illegible]	3[illegible]		4	[illegible]
Fort Pitt Bridge Works, Pittsburg Pa	[illegible]	12,511 00	2½	7	4	[illegible]
Milwaukee Bridge Co, Milwaukee Wis	[illegible]	11,8[illegible] 00	[illegible]	1½	2¼	[illegible] 961 00
Modern Steel Structural Co, Waukesha Wis.	[illegible]	11,587 [illegible]	3½	8	[illegible]	[illegible]
Wisconsin Bridge & Iron Co, Chicago Ill.	21,[illegible]	12,500 [illegible]	4	5	4	37,4[illegible]
Charles Volkmann & Co, Chicago, Ill	[illegible]	[illegible]	4	5	[illegible]	[illegible]
Penn Bridge Co, Beaver Falls, Pa	24,8[illegible]	13,430 [illegible]	3.3	8	2½	[illegible]
Worden-Allen Co Chicago, Ill	[illegible]	[illegible]	3[illegible]	7	[illegible]	[illegible]
Strobel Steel Construction Co, Chicago, Ill.	[illegible]	[illegible]	[illegible]	10	5	[illegible]
King Bridge Co, Cleveland O	27,100 00	[illegible]	[illegible]	5	4½	40,400 00
National Contracting Co, Chicago, Ill	[illegible]	[illegible]	3½	4.6	4	40,8[illegible]

Peoria, Ill.—Bridge.—J. S. Allen & Co., Peoria, at $1,055, for constructing bridge in Rosefield Township.

Wichita, Kan.—Bridges.—Wichita Construction Co., Wichita, Kan., at $8,650, for constructing bridges over Arkansas River at Lawrence Ave., for the county, and at $1,000 for a 40-ft. steel bridge on 21st St.; C. E. Carr, at $1,690, each, for erecting three steel bridges for county.

Louisville, Ky.—Sewers.—Henry Bickel Co., at about $30,000, for constructing the Hoertz Ave. sewer, and the Schultz & Vogt Co., at about $12,000, for constructing the Auburn Ave. sewer, for the Sewerage Commission.

Anoka, Minn.—Ditch.—J. J. Hankerson, Glencoe, Minn., at $7,470, for constructing Ditch No. 49, requiring 83,000 cu. yds. of excavation.

Ludington, Mich.—Bridge Work.—Joliet Bridge Co., Joliet, Ill., at $3,800, for completing bridge over Lincoln Lake, by extending structural work about 250 ft., and constructing cement floor.

Springfield, Mo.—Sewer.—John Spandri, for constructing sewer in District No. 12.

Omaha, Neb.—Foundation Excavation.—J. L. Brandels & Sons let the contact for excavating for the new theater building at Seventeenth and Douglas Sts. to Lamoreaux & Peterson of this city.

Flemington, N. J.—Macadam Road.—Van Keuren & Son, Newark, N. J., at $38,890, for constructing about six miles of macadam road for county.

Jersey City, N. J.—Paving.—J. F. Shanley, for paving with brick on Randolph Ave.

Glendive, Mont.—Building.—W. T. Perham, Miles City, Mont., for erecting $35,000 high school building for Dawson County.

Hillsdale, N. J.—Macadam Road.—H. B. Sproul, Binghamton, N. Y., at $35,900, for grading and macadamizing a road in this township.

Muskogee, Okla.—Storm Sewer.—McCormick Constructing Co., St. Louis, Mo., at $117,309, for constructing storm sewers in two districts and the Heman Construction Co., Fullerton Bldg., St. Louis, Mo., at $68,351, for constructing storm sewers in one district.

Chattanooga, Tenn.—Paving.—West Construction Co., at $48,460, for paving Broad St. with asphalt; Southern Paving & Construction Co., at $13,160, for paving Hooke St. with brick.

Guymon, Okla.—City Hall.—Ballinger & Fischer, for building new city hall.

Erie, Pa.—Sewers.—J. J. & M. E. Doyle, for constructing 18-in. sewer in Wallace St. and a 12-in. sewer in 8th St.

Galveston, Tex.—Concrete Drain.—Heffron & Falligant, Galveston, at $37,575, for constructing reinforced concrete drain for city.

San Antonio, Tex.—Church.—Haynes, San Antonio, for erecting church building for the First Presbyterian Church.

Houston, Tex.—Ditch Work.—F. B. Arpion, Grand Rapids, Wis., at $52,172, for ditch work in Harris County Drainage District No. 1, the work including 350,000 cu. yds. of ditching.

Stamford, Tex.—Bridges, Etc.—Jarrett Construction Co., Springfield, Mo., for the construction of all bridges and buildings along the line of the proposed Stamford & Northwestern R. R.

Salt Lake City, Utah.—Bridge.—Minneapolis Steel & Machinery Co., Minneapolis, Minn., at $4,192, for furnishing and erecting riveted steel highway bridge, including foundation and approaches with two sidewalks, over the Indian River at North Temple St.

Norfolk, Va.—Bridge.—Receivers of the Norfolk & Southern Ry. Co. have let a contract to the McLean Construction Co., the firm that is building the Virginian Railway pier at Sewall's Point, for the completion of the million-dollar bridge of the Norfolk & Southern across Albemarle sound. A portion of the bridge had been begun when the road went into the hands of the receivers and the finishing of the contract was made possible by the recent issuance of receivers' certificates. The bridge is over five miles in length. One end of the bridge is at Edenton and the other at Mackles Ferry, N. C. An allowance of $560,000 was made for the completion of the bridge.

Cody, Wyo.—Road Work.—David Lewis, Cowley, Wyo., at $3,475, for constructing road for county.

PROJECTED WORK.

Bridges.

Items Arranged Alphabetically by States.

Selma, Ala.—County Commissioners have ordered the construction of a bridge over Cane Creek, a bridge over Dry Creek and a bridge over Boguechitto Creek. The bridges will be of iron and steel with concrete floors.

Fort Morgan, Colo.—State Legislature is to be asked to establish a bridge half way between this place and Brush. T. W. Jaycox, Denver, Colo., is State Engineer.

Napa, Cal.—Local Chamber of Commerce is advocating the construction of the proposed state bridge over Carquinez Strait. It is proposed to have a suspension bridge extending from the bluff at South Vallejo to the shore at Vallejo Junction.

Norwich, Conn.—The New York, New Haven & Hartford R. R., W. H. Moore, New Haven, Conn., Engineer of Bridges, will, it is stated, soon commence work on the construction of a new bridge to take the place of the one now spanning the Thames from Winthrop's Point to the Groton shore. The bridge will be a lift structure.

Atlanta, Ga.—An appropriation of $66,000 will be asked for the construction of a bridge at Gray St. to connect Jones Ave. with the Exposition Cotton Mills District. R. M. Clayton is City Engineer.

Des Moines, Ia.—The city has received from the various railroads interested revised plans for the proposed viaduct at 7th St. The Chicago, Burlington & Quincy R. R., C. H. Cartlidge, Bridge Engineer, Chicago, Ill., is interested.

Dubuque, Ia.—City Engineer has drawn up plans and specifications for a viaduct to be built by the Chicago, Milwaukee & St. Paul R. R. from Johnson and Garfield Aves. to Sycamore St. Plans have been drawn for a concrete structure to cost $30,000 and for an iron structure to cost $45,000.

Manchester, Ia.—Supervisors of Delaware and Jones Counties have decided to construct a joint county bridge over the Maquoketa River.

Peoria, Ill.—Representatives of the subsidiary lines of the Peoria & Pekin Union Ry. held a meeting Jan. 21 to decide upon the type of bridge to be erected over the Illinois River at Peoria. W. E. Emery, Peoria, Ill., is Chief Engineer of the Peoria & Pekin Union Ry.

West Point, Ky.—The Lincoln Park Association is still agitating for the construction of a bridge over Salt River at West Point.

Bangor, Me.—The Bangor Ry. & Electric Co., John R. Graham, President, has made proposition to the city council for the construction of a new bridge over the Penobscot River between Bangor and Brewer.

Towson, Md.—Baltimore County is to spend about $300,000 the present year for bridge work and road improvements. Henry G. Shirley is County Road Engineer.

St. Paul, Minn.—State Legislature is to be asked to appropriate $400,000 for a wagon bridge across the Mississippi River at Minnesota St.

Kansas City, Mo.—The U. S. War Department has approved the plans of the Union Pacific R. R., Russel L. Huntley, Omaha, Neb., Chief Engineer, for raising and lengthening its bridge over the Kaw River.

Springfield, Mo.—County Commissioners have been petitioned to construct a bridge over Sac River at the Phillip Sneed ford on Willard and Glidewell Road.

Cape May, C. H., N. J.—County Free Holders have appointed a committee, of which Director Anthony B. Smith is a member, to act with the State Boulevard Committee in reference to connecting Cape May and Atlantic Counties by means of a bridge between Somers' Point and Ocean City.

Omaha, Neb.—City Council has passed an ordinance directing various railroad companies to construct a viaduct over the tracks from 30th and Bancroft to 26th and Walnut Sts.

Portsmouth, N. H.—The Boston-Maine R. R. is considering building a new $350,000 bridge over the Pisqutaqua River. J. P. Snow, Boston, Mass., is Bridge Engineer.

Cincinnati, Ohio.—The City will have work started shortly on the construction of the proposed Gilbert Ave. viaduct; a bond issue of $283,000 was authorized some time ago for the work. The bridge will probably be built of reinforced concrete and will be 1,200 ft. long, 80 ft. wide and 30 ft. high. Frank Morris is City Bridge Engineer.

Barberton, Ohio.—Engineer Alcorn is preparing plans, profiles and estimates for the proposed Cornell St. viaduct. The structure will probably cost about $70,000.

Cleveland, O.—Park Engineer Stinchcomb is preparing plans for a [illegible],000 bridge over Big Creek.

Cleveland, O.—Ordinance is to come before the City Council authorizing a vote on the question of issuing $1,000,000 worth of bonds for replacing swinging span of the Superior Ave. viaduct with a bascule bridge, removing the center pier and repairing the masonry arches and in the elimination of the Central viaduct draw.

Sulphur, Okla.—Midland Bridge Co., Kansas City, Mo., at $5,493, was the only bidder Jan. 14 for constructing a steel bridge over Rock Creek for the United States Government.

Temple, Tex.—The Atchison, Topeka & Santa Fe Ry. proposes to build a $25,000 viaduct over Adams Ave.

Granbury, Tex.—City has voted to issue bonds for building a bridge over Brazos River.

Salt Lake City, Utah.—A bill is before the State Legislature providing an appropriation for $35,000 for constructing a steel bridge over the Green River, between Green River and Elgin.

Milwaukee, Wis.—United States Engineers have approved plans of C. J. Poetsch, City Engineer, for a new bridge at Michigan St. The bridge is to have but one lift and a clear span of 80 ft. An estimate of $125,000 has been made for the bridge.

Lander, Wyo.—County Commissioners have requested a Federal appropriation of $15,000 for use in constructing bridges on the road between Lander and Yellowstone Park. The county agrees to furnish a like sum for the purpose.

Railroads.

Items Arranged Alphabetically by States.

Piggott, Ark.—The St. Louis, Kennett & Southeastern Ry., which operates a narrow-gage line 38 miles long, has perfected an arrangement with the citizens of this place by which a short line connection is to be made with the Frisco by way of the present line from Nimmons. R. H. Jones, Kennett, Mo., is president.

Pine Bluff, Ark.—The Cotton Belt R. R. is planning to expend about a million dollars in rock ballasting its track and rebuilding bridges on its line from Texas through Arkansas to Memphis. The principal portion of the work will be in rebuilding a great many of the old bridges.

Colorado Springs, Colo.—The Beaver Penrose Northern Ry. Co. has been formed and proposes to begin construction work at once on a 7-mile standard-gage railroad to connect the holdings of the Beaver Land & Irrigation Co. with the Denver & Rio Grande and Santa Fe Railroads at Beaver. The company has a capital stock of $200,000 and the road will cost $100,000. J. H. Waters, Colorado Springs, Colo., is president.

Elkhart, Ind.—St. Joseph Valley Ry., H. E. Bucklen, president, 275 Michigan Ave., Chicago, Ill., is contemplating extending its road so as to cross the gap between Elkhart and Toledo. The road is now completed from Middlebury to Angola.

Fort Wayne, Ind.—The city council has made a definite start toward track elevation through the city. The city is to pay 25% of the cost of track elevation at crossings and not for the elevation between.

Des Moines, Ia.—Des Moines, Council Bluffs & Omaha Ry. has filed its articles of incorporation and according to M. H. Miller, secretary of the company, preliminary work is to be started at once. J. W. Russell is president.

Crowley, La.—Surveys have been made between Crowley and Mellville for a route for the proposed line between the former place and Lake Arthur. The route proposed is about 20 miles in length and it is proposed to connect the line with the Orange, Gulf & Northeastern Ry. D. B. Howell, Lake Arthur, La., is interested.

Iola, Kan.—Kansas City, Olathe, Ottawa & Iola Ry Co., mentioned in our last issue under Electric Railways, has applied for a charter. The company will have a capital stock of $5,000,000 and proposes to build a railroad to be operated either by steam or electricity. It is to run from Kansas City through Olathe and Ottawa to Iola. The incorporators are J. I. Wolfe, Burlington; W. M. Riger, Burlington; J. D. Bowersock, Kansas City; Robert A. Barr, Kansas City, Mo.; W. S. Fallis, Garnett; C. H. Estabrook, Ottawa; J. P. Harris, Ottawa; Frank Hodges, Olathe; J. O. Rodgers, Iola.

Garden City, Kan.—The Garden City, Gulf & Northern R. R., mentioned in our last issue, is stated to have awarded the contract for the construction of the line from Garden City to Scott City to the Kansas Construction & Irrigation Co., of which B. M. McCue is President. The contract provides that the road must be completed and in operation by Dec. 1, 1909.

Kalamazoo, Mich.—The Kalamazoo, Lake Shore & Chicago Ry. is stated to be planning to make a number of improvements to its line this year. H. D. Swayze, Paw Paw, Mich., is General Superintendent.

Tucumcari, N. Mex.—The Tucumcari-Memphis Ry. Co., a subsidiary company of the Rock Island, has been incorporated in New Mexico and will complete the Choctaw extension to Tucumcari, begun several years ago, but abandoned two years ago. The capital stock of the company is $1,500,000 and the headquarters are at Chicago, Ill. B. L. Winchell, 144 Van Buren St., Chicago, Ill., President of the Chicago, Rock Island & Pacific R. R., is one of the incorporators.

Jamestown, N. Dak.—Advices from this place state that the construction work on the Midland Continental R. R. will be actively commenced on May 1. It is stated that Locating Engineer Beach has been directed to engage 500 teams for grading. Three crews are to be put to work, one working from Edgeley, one from Jamestown, and the other between the two places.

Sharon, Pa.—The Sharon R. R. Co., now operated by the Erie R. R. Co., is to be improved this spring, it is said. The company has voted to expend $750,000 on double-tracking the road between Terana and Newcastle and in building a roundhouse and a number of switches.

Pittsburg, Pa.—Joseph Ramsey, Jr., President of the New York, Pittsburg & Chicago Air Line R. R., is quoted in the local press reports as stating that actual construction work will be begun this year on the proposed road. It is stated that arrangements have been made to secure the necessary capital to go ahead with the work. The company was incorporated some time ago with a capital stock of $1,000,000. The line between Pittsburg and New York will be 300 miles long and will be low-grade, double track. It is to be operated by electric locomotives from the beginning. It is estimated that the road can be built in three years.

Pittsburg, Pa.—The Gilmore & Pittsburg R. R. Co., Ltd., will receive bids at once for constructing a 120 mile standard gage steam line in Idaho and Montana. Contracts for portions of the heavier work, including a 750 ft. tunnel, will be let at once. The work will cost about $3,000,000 and bidders must be prepared to install on the work before March 1, 1909. Bid will be received at the general offices of the company, 1208 Machesney Bldg., Pittsburg, Pa. T. H. Bacon is Chief Engineer and W. A. McCutcheon, President, both at the above address.

Crossville, Tenn.—The Tennessee Timber Co., which is composed of a syndicate of New York capitalists, has an engineering corps in the field locating a railroad line from Dorton, 5 miles east of Crossville, to Peavine Mountain, a distance of 7 miles. As soon as surveys are completed grading will be started, it is said. The company owns several thousand acres of timber land in this section, according to reports.

Quanah, Tex.—Acme, Red River & Northern Ry. Co. held a stockholders' meeting Jan. 21 to consider a proposition to change its name to the Quanah, Acme & Pacific Ry. Co. and to increase its capital stock and also to authorize an extension of 45 miles in Cottle County. The line at present is 6 miles long and extends from Quanah to Acme, Tex. Charles Elesminger is Chief Engineer. T. K. Hawkins, Quanah, Tex., is General Manager.

Pecos, Tex.—A $35,000 bonus has been raised here to aid the Pecos, Toyah Valley & Great Southwestern R. R., which projects a line from Pecos to Balmorhea. M. D. Swinehart, 933 Monadnock Bldg., Chicago, Ill., promoter of the line, is quoted as stating that construction work will be started by March 1.

Abilene, Tex.—The Abilene & Southern Ry. Co., with principal office at Abilene, and a capital stock of $200,000, has been chartered and proposes to construct a line 160 miles long with a 40-mile branch, making a total of 200 miles. The incorporators are G. M. Dodge, Morgan Jones, D. T. Bomar, John W. Bomar, John W. Bread, J. M. Radford and others.

Higgins, Tex.—The Mountain Valley & Plains R. R. Co. has taken out its charter in Texas. The capital stock is $1,000,000 and the principal office is at Higgins. The road will be built from the west boundary line of Hartley County and in an easterly direction to the eastern line of Lipscomb County, through the town of Higgins and through the counties of Hartley, Dallam, Sherman, Moore, Hutchison, Hansford, Ochiltree and Lipscomb. The incorporators are C. S. Harrington, Del W. Harrington, C. M. Kella, W. F. Felton, Ben O. Boyce, E. C. Gray and A. L. Winsett.

Paris, Tex.—Paris & Mt. Pleasant R. R. has been organized to build a railroad between Paris and Mt. Pleasant. The company is to have a capital stock of $75,000, practically all of which has already been subscribed. R. J. Scott, Paris, Tex., is President.

Madison, Wis.—The State Railroad Commission has authorized the Minneapolis, St. Paul & Sault Ste. Marie R. R. to increase its capital stock from $21,000,000 to $42,000,000. Thomas Green, 317 2d Ave., South Minneapolis, Minn., is Chief Engineer.

Electric Railways.

Items Arranged Alphabetically by States.

Citronelle, Ala.—The construction of an electric railway between this place and Mobile is under construction. George N. Bressler, Mobile, Ala., is interested.

Florence, Ala.—The Sheffield Co., J. B. McClary, General Manager, Sheffield, Ala., is considering extending its electric line to the Florence University, 8 miles north of the city.

Yellville, Ark.—The local Commercial Club is securing the right-of-way for an electric line from Rush Mining Camp to this place.

Helena, Ark.—The Helena Street & Interurban Co. has had surveys made and will let contracts shortly for the construction of its proposed 10-mile line in Helena and adjacent territory. J. W. Burk, Jr., Helena, Ark., is President.

Pasadena, Cal.—The Pasadena Rapid Transit Co., mentioned in our last issue, has taken over the old Cycleway Co. and in that way secured right-of-way between Pasadena and Los Angeles. It is expected that actual construction work will be started in the spring. The road will be over a private right-of-way and will be double-track and standard-gage. Horace H. Dobbins, Los Angeles, Cal., is President. Don Porter, Pasadena Cal., is also interested.

Grand Junction, Colo.—City council has passed ordinance granting the Grand Junction Electric Ry. Co. the right to extend its line up 4th St., along Gunnison and down 10th St.

Wallace, Idaho.—Project for an electric railway between Wallace and Cocur d'Alene has been revived. W. J. Hall, Chief Accountant of the Federal Mining & Smelting Co., who has the franchise, has asked for re-enactment of the city ordinance giving the company right to enter Wallace. About $20,000 has been spent in securing right-of-way and making surveys.

Rock Island, Ill.—The Galesburg & Rock Island Traction Co. has been incorporated and proposes to build an electric line from Galesburg to Rock Island via Alexis. The principal office will be located in Rock Island. The incorporators include Frank H. Clark, Springfield, Ohio, and R. V. Field, Galesburg, Ill.

Morris, Ill.—The Chicago, Ottawa & Peoria Ry., the McKinley interurban line, has accepted the one-year extension to its franchise granted by this city for building a line between Morris and Seneca. This work will be started as soon as the weather conditions permit, it is said. W. B. McKinley, Champaign, Ill., is interested.

Galesburg, Ill.—The People's Traction Co., of which the Knox Engineering Co., Chicago, Ill., is Engineers, has decided to build an electric interurban between Galesburg and Galva. Right-of-way is to be secured and surveys started soon. The line will be an extension from Abingdon, the present terminus, and will be 24 miles long.

Aurora, Ill.—A syndicate of Aurora, De Kalb and Elburn men are raising money to take over the Aurora & De Kalb line, with the object of operating it as an electric railway. F. C. Eckman, Aurora, Ill., is General Manager of the Aurora & De Kalb line. The line is 35 miles long.

Waukegan, Ill.—The Waukegan, Rockford & Elgin Traction Co. has been incorporated with principal office at Waukegan and a capital stock of $1,500,000. The company proposes to construct an electric railway from Waukegan to Woodstock, Marengo, Rockford, Belvidere, Elgin, Antioch, Millburn. The incorporators are Robert D. Wynn, Claire C. Edwards, John D. Pope, Fred Bairstow and Dr. John Foley, all of Waukegan.

New Albany.—The New Albany & Paoli Plank Road Co. is seeking to have its charter amended so that it can have a right to construct an electric road on its right-of-way. The object of this is to place the company in a position enabling it to dispose of its property to any company that desires to use a portion of the roadway for an electric line right-of-way.

Bluffton, Ind.—Elections are to be held in four townships in Wells and Adams Counties to vote subsidies amounting to $34,000 for the proposed Bluffton, Berne & Celina interurban line. Franchises have been granted the company in Celina, O., the eastern terminal, and at Berne, the midway point. The survey has been completed and the right-of-way has been secured for three-fourths the distance. Joel Gerber and Peter Neuenschwander are interested.

Kalamazoo, Mich.—The Michigan United Electric Ry. Co., Lansing, Mich., is considering building a branch line from Kalamazoo to South Bend to tap an interurban line at that point for Chicago connections.

Saginaw, Mich.—Right-of-way is nearly all secured for the proposed Saginaw, Owasso & Lansing Electric Ry. and J. A. Thick, promoter of the road, is quoted as stating that construction work will be started in the spring.

Kansas City, Mo.—The Kansas City & Southeastern Traction Co. has completed final surveys to Lee's Summit and has secured 90% of the right-of-way. Contracts for the track and roadbed construction are to be awarded at once, it is said. The road will be operated by means of the third-rail system. The work of construction will be done under direction of the Missouri Interurban Co., an auxiliary of the main company. Charles A. S. Sims is interested.

St. Joseph, Mo.—Advices from this place state that work on the interurban line between St. Joseph and Kansas City will be commenced in the spring. Senator E. D. Martin, Marshall, Mo., Vice-President of the company, has been in the East conferring with contractors.

Brooklyn, N. Y.—The South Flatbush R. R. Co. has been organized by a syndicate of Brooklyn and Philadelphia real estate men, headed by John C. Langan, to construct a surface trolley road about three miles long to connect Brighton Beach and Flatbush Ave. lines of the Brooklyn Rapid Transit Co.'s system.

Houston, Tex.—The Houston Electric Co has been having surveys made for extension of its line in Houston Heights for a distance of about one mile.

Cleburne, Tex.—B. G. Lenk of Fort Worth, Tex., has been making surveys for the proposed Fort Worth-Cleburne line.

Walla Walla, Wash.—Contracts will be let about Mar. 1 for the construction of the proposed 70-mile line by the Walla Walla & Columbia Traction Co. The proposed road is to run from Dayton to Huntsville, Wartsbury and Walla Walla. N. G. Blalock, Walla Walla, Wash., is President.

Wauwatosa, Wis.—The Wisconsin Traction, Light, Heat & Power Co., John I. Beggs, President, Milwaukee, Wis., will start work soon on the extension of its line from Wauwatosa to Oconomowoc by way of Elm Grove, Brookfield, Duplainville, Pewaukee, Hartland, Nashotah, Nagowicka and Giffords.

Sewers.

Items Arranged Alphabetically by States.

Little Rock, Ark.—Storm sewer to cost $10,000 is to be constructed for this city. E. A. Kingsley is City Engineer.

Bisbee, Ariz.—There is to be an extension of a sewer along Maxfield Ave.

Los Angeles, Cal.—Board of Public Works is considering installing sewer in Commonwealth Ave.

Modesto, Cal.—City Trustees have issued a call for a $100,000 bond issue for public improvements, to include sewers, street work, city hall and a fire department building.

Corona, Cal.—City is having plans prepared for storm and sanitary sewers. H. Clay Kellog, Santa Ana, Cal., is Engineer.

Mendota, Ill.—City is considering installing sewers for Sewer District No. 2 in North Mendota.

Springfield, Ill.—City Council is considering plans for construction of a sewer in the Sixth Ward to cost $13,460.

Grundy Center, Ia.—City Council has passed ordinances for the construction of sewers and contracts will be let soon. The Iowa Engineering Co., Clinton, Ia., is the Engineer.

Lebanon, Ind.—City Council has ordered City Engineer to prepare plans for a sanitary sewer in the southern portion of the city. The sewer will cost about $75,000.

Baltimore, Md.—Board of Public Improvements has passed ordinance providing for a sewer in Eastern Ave. from the eastern city limits to Harford run sewer in Lakewood Ave. B. T. Fendall is City Engineer.

Baltimore, Md.—C. W. Hendrick, Chief Engineer Sewerage Commission, has prepared specifications for the construction of the series of lateral sewers to be built in connection with the sewer system. These laterals will cost about $100,000.

Winchendon, Mass.—Special town committee may be called soon to consider installing a new sewer system. Plans have been prepared showing that sewers will cost about $75,000. Charles L. Day is Selectman.

Attleboro, Mass.—Town meeting was held Jan. 16 to take action on authorizing the town to incur an indebtedness of $300,000 for installing a sewer system.

Ypsilanti, Mich.—City Council has voted to construct sewer in Bell St.

Wyandotte, Mich.—The Board of Public Works has directed Mason L. Brown, Consulting Engineer of Detroit, Mich., to prepare plans and specifications for sewers in the recently acquired territory of West Wyandotte and South Detroit. The estimated cost of the sewers is $60,000.

St. Paul, Minn.—Sewers to cost about $140,000 are to be constructed for this city. The Hamline-Jefferson system up to Summitt Ave. is the largest item. This sewer will cost $50,000. L. W. Rundlett is City Engineer.

Utica, N. Y.—City Engineer is preparing plans for a 5,000-ft. storm water sewer to be constructed in Auburn Ave.

Buffalo, N. Y.—F. W. Ward, Commissioner of Public Works, is to ask the Common Council for an appropriation of $150,000 to lower the Bird Ave. sewer.

Carrington, N. Dak.—City is considering installing sewer system.

Upper Sandusky, O.—City Council is considering extending the N. 7th St. sewer to the outlet.

Sandusky, O.—Council has passed ordinance to construct sewers in Cable Park.

Akron, O.—Board of Public Service will request Council to pass ordinance providing for the cleaning of catch basins by contract.

Lockland (P. O. Cincinnati), O.—Village will soon call for bids for constructing a sewage disposal plant to cost $10,000.

Pittsburg, Pa.—Department of Public Works, A. B. Sheppard, Director, is preparing plans and estimates for the construction of a main sewer to follow the course of Saw Mill run in the west end.

Harrisburg, Pa.—City officials are taking the first steps toward preparing for sewage disposal. The cost of the scheme is estimated at from $1,500,000 to $200,000,000. M. B. Cowden, City Engineer, is in charge.

Wolsey, S. Dak.—City Council is to be asked to call special election to vote on issuing $6,000 of bonds for the construction of a sewer system and the improvement of the water works.

Ipswich, S. Dak.—City will probably let contracts early in the spring for the construction of a sewer system and sewage purification plant. The Dakota Engineering Co., Mitchell, S. Dak., is Engineer.

Chttanooga, Tenn.—County Court is to construct a $3,000 sewer from the County Work House and Poor Asylum to Wolf River.

Dallas, Tex.—Park Board is considering constructing adequate sewer service for the Fair Park.

Provo, Utah.—Part of the city sewer system is to be rebuilt.

Norfolk, Va.—Resolution has been before the Council to appropriate $16,000 for the purpose of installing an additional pump at the Colley Ave. sewer pumping station and building a house over the same.

Oshkosh, Wis.—Council has passed ordinance for issuing $26,500 of bonds for sewer construction.

Lacrosse, Wis.—Resolution has been before the Council for bonding for $85,000 for constructing a trunk sewer along Mississippi St. and a sewer in Mill St.

St. Thomas, Ont.—City has voted to issue $40,000 of bonds for installing septic tanks for city sewer system. W. B. Doherty is City Engineer.

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DITCH WORK.

Fowler, Ind.

Open bids will be received for the construction of the W. B. Curtis joint ditch, situated in Round Grove Township, White County, and Pine Township, Benton County, Indiana, at 1 p. m. on Thursday, Feb. 18, 1909, at the office of County Surveyor of Benton County, Fowler, Indiana.

Said ditch is eight (8) miles north of Otterbein, Indiana, and consists of 7,100 feet of tile and 31,300 feet of dredge work.

The tile to be of the following sizes: From "O" to Station 11, 12-inch tile; from Station 11 to Station 31, 14-inch tile; from Station 31 to Station 51, 16-inch tile; from Station 51 to Station 71, 18-inch tile.

The dredge contains 255,292 yards; the width of bottom is 10 feet; the maximum cut is 20.74 feet; 8-foot berm; average depth of tile is 5.75 feet; average depth of dredge 12.69 feet.

The above will be let in two contracts, one for tile and one for dredge.

A certified check for $1,000.00 must be filed by prospective bidders as evidence of good faith.

The superintendent reserves the right to reject any or all bids.

CHESTER B. WHICKER,
Supt. Construction.

WATER-WORKS.

Sebree, Kentucky.

Sealed proposals will be received by G. W. Cavanah, Town Clerk, until 12 o'clock, noon, Feb. 15th, for constructing a complete system of water works. The work will comprise, in the main, one 60,000-gallon steel tank, small frame building, said building to contain boiler, two pumps, etc., distribution pipe line system. Certified check of 5 per cent of amount of each bid on any part of the work, and in no case less than Fifty Dollars ($50.00) enclosed, all checks payable to C. H. Ramsey, Mayor. Plans, etc., at office of Town Clerk.

G. W. CAVANAH, Clerk.

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DREDGE WORK.

Logan, Iowa

Bids will be received by the Auditor of Harrison County at Logan, Iowa, up to 10 a. m. February 10th, for the dredge work on the Boyer River Improvement Ditch, in said county. The ditch is 6.38 miles long and the excavation amounts to 311,000 cubic yards. Construction work to commence on or before April 15, 1909, and be completed by January 1, 1910. For copies of specifications, contract and other information apply to

G. W. ATKINS, Auditor
Logan, Iowa
Or to SETH DEAN, Cons. Engineer,
Missouri Valley, Iowa.

PROPOSALS FOR A SEWER SYSTEM AND PUMPING PLANT.

East St. Louis, Ill., Jan. 14, 1909.

Proposals will be received by the Board of Local Improvements of the City of East St. Louis, Ill., until 12 o'clock noon, February 17, 1909, for the construction of a system of concrete and pipe sewers and a sewage pumping station as follows:

One pumping station building and appurtenances.

Five drainage and two sewage pumping engines to be vertical, single-acting gas engines, direct connected to horizontal shaft centrifugal pumps.

33,500 linear feet of sewers, varying in diameter from 3 to 10½ feet.

The work will be paid for in cash or bonds. Specifications, plans, form of proposal and other information may be obtained from the engineer of said city upon a deposit of $5.

W. J. CROCKEN, City Engineer.

WATER-WORKS.

Wichita, Kan.

Sealed proposals will be received at the office of the City Clerk until 7:30 o'clock p. m., March 15, 1909 for the construction of a water works system for the City of Wichita, Kan. All work and material to be done and supplied according to plans and specifications on file in the office of the City Clerk. All work to be done under the direction and supervision of a special engineer to be employed by the city. The work will be paid for in cash or four and one-half per cent. twenty-year bonds, at the option of the city. Plans and specifications were prepared by Engineer Hiram Phillips of St. Louis, copy of which may be obtained by applying to the City Clerk upon deposit of twenty-five ($25.00) dollars.

The estimated cost of the above improvement is approximately $860,000. All bidders will be required to enclose certified check in the sum of $10,000, as a guarantee of good faith. The Mayor and Council reserve the right to reject any and all bids.

R. N. DORR, City Clerk

FORT MYER, VA., January 11, 1909. Sealed proposals in triplicate will be received at the office of the Constructing Quartermaster, until 11 o'clock a. m., February 9, 1909, and then opened for the construction of a Band Stable at Fort Myer, Va. Certified check or Surety Company's guarantee for 10 per cent of the amount must accompany each bid. Plans and specifications will be furnished upon application accompanied by a deposit of $5.00 to insure safe return. The government reserves the right to reject any or all bids. Proposals should be indorsed "Proposals for Band Stables," and addressed to CAPTAIN B. B. HYER, Constructing Quartermaster.

WATER MAINS, STEEL TANK, PUMPING STATION, ETC.

Minot, No. Dak.

The City Auditor of the City of Minot, No. Dak., will receive bids on the 4th day of February for the construction of a concrete and brick pumping station complete with pumps, filters, etc.; also steel water tower and tank and about eleven (11) miles of mains from 6 to 16-inch.

E. S. SEVERANCE, City Engineer.

STREET PAVING.

Olympia, Wash.

Bids will be received by the City of Olympia, Wash., until 5 p. m., Feb. 1, 1909, for constructing about 17,000 square yards of vitrified brick or creosoted wood block pavement, 11,700 square yards of concrete sidewalks, 17,000 lineal feet of concrete curb. Work to begin May 1, 1909.

J. R. DEVER, City Clerk.

CONCRETE RESERVOIR.

New Ulm, Minn.

Bids will be received by the City Clerk, New Ulm, Minn., up to 5 p. m., Feb. 15, for constructing a covered reinforced concrete reservoir of 1,000,000 gallons capacity for the City of New Ulm, Minn.

ERNST WICHERSKI, City Clerk

KEY WEST, FLORIDA. Sealed proposals in duplicate will be received by the undersigned until 11 a. m., February 5, 1909, and then publicly opened for furnishing a condenser, filter feed water heater, etc.; also for remodeling pumping and distilling plant at Key West Barracks, Fla. Plans and specifications on request. Proposals should be marked "Proposals for pumping plant" and addressed to CAPTAIN C. H. LANZA, Quartermaster, Key West, Florida

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COURT HOUSE.

Omaha, Neb.

Notice is hereby given that the Board of County Commissioners for the County of Douglas and State of Nebraska will receive bids for the construction of a Court House for Douglas County, according to the plans and specifications on file in the office of the County Clerk of said county. Bids will be addressed to D. M. Haverly, County Clerk, enclosed and sealed in properly endorsed envelopes, and filed with him not later than March 1, 1909, at 12 o'clock noon, at which time said bids will be opened.

Copies of the plans and specifications can be obtained from the undersigned or from the Architect, John Latenser, 632 Bee Building, Omaha upon application. A certified check for $50.00 must accompany all applications for plans, as a guarantee that bids will be submitted on the same, the check to be returned when the bids are opened.

All bids must be submitted on blank proposals, which will be furnished on application by the County Clerk, or John Latenser, Architect.

Samples of stone and granite upon which bids are based must accompany each bid.

Each bidder must submit with his proposal a certified check in a sum equal to 3 per cent of such proposal, the same to be drawn in favor of the Board of County Commissioners of Douglas County, Nebraska.

The Board of County Commissioners reserves the right to reject any and all bids.

D. M. HAVERLY,
County Clerk, Omaha, Neb.

PAVING.

Indianola, Iowa.

Sealed proposals will be received by the City Clerk, Indianola, Iowa, until 7 o'clock p. m., on the 8th day of February, 1909, for construction in said city of about 15,390 square yards of 3-inch creosoted wood block paving on a 5-inch concrete foundation and about 7,884 lineal feet of 6 by 20-inch concrete curb and about 450 yards of extra grading, according to plans and specifications now on file in City Clerk's office. Each bid must be accompanied by certified check for $1,500. For proposal blanks, etc., address

ARTHUR LEE, City Clerk.

PROPOSALS FOR CONSTRUCTION OF **barracks and quarters, and plumbing and heating and electric wiring same. War** Department, office of the Constructing Quartermaster, New London, Conn., November 28, 1908. Sealed proposals for constructing one double barrack, one single barrack, two field officers' quarters, one four-set officers' quarters, two lieutenants' quarters, three double non-commissioned officers' quarters, and one double firemen's quarters, at Fort Terry (Plum Island), New York, and two double barracks, two field officers' quarters, four lieutenants' quarters, two double non-commissioned officers' quarters, and two double firemen's quarters, at Fort H. G. Wright (Fisher's Island), New York, and for plumbing, electric wiring and installing heating plants in same will be received here until 10 a. m., Feb. 10, 1909, and then opened. Proposals are desired for brick construction of all buildings and for reinforced concrete construction on bidders' plans of barracks and non-commissioned officers' and firemen's quarters. Information furnished on application. Envelopes containing proposals should be endorsed: "Proposals for Public Buildings," and addressed: "R. M. Schofield, Major, Q. M., Constructing Quartermaster, New London, Conn."

GAS PRODUCER AND GAS ENGINE ELECTRIC LIGHTING PLANT.

Milwaukee, Wis., Jan. 6, 1909.

Sealed proposals will be received at this office until Wednesday, Feb. 17, 1909, at 10:30 o'clock a. m., for furnishing and erecting complete in running order ready for use, in buildings and on foundations to be furnished by the city of Milwaukee, all the machinery and appurtenances thereto, necessary to make a complete installation of a gas producer and a gas engine electric lighting plant, said plant to be located on blocks 70 and 95, on the corner of Walker and Davidson streets, in the Fifth ward of the city of Milwaukee, according to plans and specifications (dated Dec. 24, 1908) on file in this office.

Work to be completed within ten months from the date of the award of the contract, failing in which the contractor shall pay to the city of Milwaukee as liquidated damages the sum of $750 per day for each and every day's delay in completing the work.

Bonds to accompany bids required in the penal sum of $45,000, or in lieu thereof the bidder may deposit with the board of public works the sum of $22,500 in money or certified bank check.

In case bonds are submitted with bids, local bondsmen or a surety company authorized to do business in the state of Wisconsin will be required.

All moneys deposited will be returned to unsuccessful bidders on award of contract and to successful bidder when contract is entered into.

Plans and specifications will be furnished to prospective bidders on the receipt of $25 as a guarantee for their safe return.

CHARLES J. POETSCH,
J. P. SHERER,
L. A. JANSEN,
A. J. GRUNDMAN,
Commissioners of Public Works.
AUGUST M. GAWIN, Comptroller.

PAVING.

Moorehead, Minn.

Sealed proposals will be received until 8 p. m., Feb. 1, 1909, at the office of the City Clerk, for the construction of pavement according to plans and specifications therefor. Plans and specifications are on file and may be seen at the office of the City Clerk, Moorhead, Minn.

Bids will be submitted to the City Council and opened at a council meeting to be held at the City Hall at 8 p. m., Feb. 1, 1909.

Proposals will be received made out on blank forms furnished by the city through its Engineer, Mr. A. M. Hopeman.

Each bid must be accompanied by a properly certified check upon any reputable bank in the state of Minnesota, in the sum of at least 10 per cent of the amount bid, and made payable unconditionally to the order of Mr. O. C. Beck, City Treasurer, as a guarantee that the successful bidder will enter into a contract with the City of Moorhead in accordanec with the plans and specifications and price bid, and furnish a satisfactory bond in a sum equal to 50 per cent of the total amount of the bid, for the faithful performance of the contract.

The right is hereby reserved by the City of Moorhead to reject any or all bids or any part of any bid.

By order of the City Council.

H. E. ROBERTS, City Clerk.

WATER-WORKS.

Hugo, Oklahoma, Jan. 8th, 1909.

Notice is hereby given that the City Council of Hugo, Oklahoma, will, until 8 p. m., February 2d, 1909, receive bids at the City Clerk's office, to furnish materials, tools and labor for the construction of a water-works plant for Hugo, Oklahoma, according to plans and specifications on file with the City Clerk, and also in the office of Hiram Phillips, St. Louis, Missouri.

The magnitude of the work to be done is about as follows:

One brick Power House.
One 3-million gallon concrete reservoir.
Two 150 H. P. tubular boilers.
Two 2-million gallons pumps, each.
Two 800 cu. ft. Air Compressors each.
4,185 ft. 14" cast iron pipe.
1,790 ft. 12" cast iron pipe.
1,610 ft. 10" cast iron pipe.
5,510 ft. 8" cast iron pipe.
55,485 ft. 6" cast iron pipe.
14,365 ft. 4" cast iron pipe.
135 Fire Hydrants.
Two 14" valves.
One 12" valve.
One 10" valve.
Seven 8" valves.
Forty-five 6" valves.
Twenty-two 4" valves.
700 Water Meters.
Material for 700 House Connections.

Bids must be made upon blanks furnished by City Clerk, which will be furnished upon application.

A set of blue prints and specifications will be furnished by the Council upon receipt of $3.00, which will be refunded upon receipt of bid and return of plans and specifications.

The Council reserves the right to reject any or all bids.

A deposit of 5% of amount of bid must accompany bid.

W. L. GIBBS,
Attest: Acting Mayor.
W. T. ECHOLS, Clerk.

WATER METERS.

Jamestown, No. Dak.

Bids wanted for the furnishing of meters for the water system of the city of Jamestown, No. Dak., in lots of 25 and 50.

The city reserves the right to reject any and all bids. All bids must be filed in the office of the undersigned not later than 3 o'clock Monday, February 1, 1909.

G. E. LYMAN, City Auditor.

FOR SALE

No. 1 site for making Portland Cement and generating electricity in West Virginia on the Potomac river, 2,500 water horse power, inexhaustible supply of material of the finest quality, fine shipping facilities, railroad and C. & O. canal. Very little cash required to purchase this valuable property.

W. T. TIPPETT,
11 E. Lexington Street, BALTIMORE, MD.

DRAINAGE DITCHES AND LEVEES.

Atkinson, Ill., Jan. 9, 1909.

Sealed proposals will be received by the Commissioners of the Drainage Union District Number One of the Towns of Atkinson and Alba, in Henry County, Illinois, until Saturday, the 6th day of February, 1909, and until 2 o'clock p. m. of said day, at which time the bids will be publicly opened at the Bass School House, located on the southeast quarter of the southeast quarter of Section 15, in Atkinson Township, Henry County, Illinois, and within the boundaries of said district. The work for which the bids are desired consists of the construction of 41,300 feet of open ditches with a total estimated excavation of 163,300 cubic yards and 3,400 feet of levees with an estimated fill of 2,800 cubic yards. This work is suitable for either dry land or floating machines. Specifications for the work may be had upon application to the Engineer, or they may be seen with the plat and profiles at the office of the Engineer or Town Clerk A copy of the plat and profiles may be procured from the Engineer upon the payment of $1.00. The place of letting is two miles north of Atkinson, on the C., R. I. & P. R. R.

H. E. REEVES, Engineer,
Atkinson, Ill.
HENRY STELCK, Attorney,
Rock Island, Ill.
EDWARD NOWERS, Atkinson, Ill.
ANDREW W. ALLEN, R. F. D. No. 6, Geneseo, Ill.
JOHN FRANKENREIDER, Annawan, Ill.
Commissioners in and for said Drainage District.

TUNNEL SEWER.

Niagara Falls, N. Y., Jan. 25, 1909.

Sealed proposals will be received by the Board of Public Works of the City of Niagara Falls, N. Y., at the City Building in said city, up to Tuesday, February 9, 1909, at 7:30 o'clock p. m., for the furnishing of materials and the construction of the following work:

No. 202. A tunnel trunk sewer from the end of the present tunnel at Sugar Street to Royal Avenue and in Royal Avenue and Royal Avenue extended to Union Street.

No. 203. A sewer in Union Street from the end of the proposed tunnel to Buffalo Avenue.

All proposals must be made on blank forms, which together with other requirements, may be obtained in the office of the City Engineer, Convention Hall, where plans and specifications of the work may be seen.

The Board reserves the right to reject any and all bids and to waive all informalities.

WALTER P. HORNE, City Clerk.
W. D. ROBBINS, City Engineer.

PUMPING ENGINE.

Phoenix, Ariz.

Sealed proposals will be received by the Superintendent of the Water Works of the city of Phoenix, Ariz., until 4 o'clock p. m. of Feb. 10, 1909, for one 3,000,000-gallon pumping engine. Bids must be accompanied by a certified check for 5 per cent of the amount of the bids, made payable to Frank Thomas, City Recorder. Specifications may be had upon application. Right to reject any and all bids reserved.

ROBT. A. CRAIG,
Supt. Water Works.

TANKS AND TOWER

Baltimore, Maryland

Sealed proposals, indorsed "Proposal for Construction of Water Tanks and Tower, Sanitary Contract No. 37," addressed to the Board of Awards of Baltimore City, will be received at the office of Mr. J. Sewell Thomas, City Register, City Hall, Baltimore, Md., at 11 a. m., Wednesday, Feb. 3, 1909, for constructing water tanks and tower at the sewage disposal works on Back River, as shown on plans on file in the office of Mr Calvin W. Hendrick, Chief Engineer of the Sewerage Commission.

Specifications and plans can be obtained upon application at the office of the Sewerage Commission, Room No. 901, American Bldg., Baltimore, Md., on and after Wednesday, Jan. 20, 1909. A charge of $2.50 will be made for each specification with blueprint. This charge will be refunded upon return of the unused specifications and plans in good condition.

A certified check of the bidder, on a clearing house bank, made payable to the order of the Mayor and City Council of Baltimore, for the sum of $1,000 will be required to be deposited with each bid

The successful bidder on each contract will be required to give bond and comply with the city charter respecting contracts.

The Board of Awards reserves the right to reject any and all bids.

By order of the Sewerage Commission.

PETER LEARY, JR., Chairman.
HARRY W. RODGERS, Secretary
J. BARRY MAHOOL,
President Board of Awards.

CONCRETE SEWER.

Ashtabula, Ohio, Jan. 20, 1909.

Sealed bids will be received by the Board of Public Service of the city of Ashtabula, State of Ohio, at the office of said Board until 12 o'clock, noon, Tuesday, Feb. 16, 1909, for furnishing the necessary labor and materials for the improvement of West St. from Auger Ave. to Fred St., Fred St. from West St. to Haskell Ave., Haskell Ave. from Fred St to Benefit St., Benefit St. from Haskell Ave. to Prospect St., Mills St. from Benefit St. to Hope St., Hope St. from Mills St. to Prospect St., by constructing a sewer therein, according to the plans and specifications on file in said office. The work includes approximately 1,372 lin. ft 1'10"x2'9" concrete sewer, 3,020 lin. ft of 1'8"x2'6" concrete sewer, 774 lin. ft. of 20" sewer, 2,154 lin. ft. of 15" sewer, 1,790 lin. ft. of 12" sewer, 30 manholes, and all other labor, material, branches and appurtenances, as shown by the plans and specifications, or required by said improvement.

Bidders are required to use the printed forms furnished by the city, which can be had on application at the office of said Board, and are directed to observe the "Instructions to Bidders" therein contained

The right is reserved to reject any and all bids.

By order of the Board of Public Service

A. J. RICHARDSON
Clerk

U. S. ENGINEER OFFICE, WILMINGTON, N. C., DECEMBER 30, 1908 Sealed proposals for constructing steel draw-span highway bridge with pile and concrete foundations, on Core Creek, near Beaufort, N. C., will be received at this office until 12 o'clock noon, standard time, January 30, 1909, and then publicly opened. Information on application. EARL I. BROWN, Capt. Engrs.

COURT HOUSE.

Newton, Iowa

Sealed proposals will be received by the Board of Supervisors, Newton, Iowa, until 2 o'clock p. m. on the 18th day of February, 1909, for the erection and completion of a three-story Court House for Jasper County, plans and specifications for which are now on file at the office of the County Auditor. Plans and specifications can also be seen at the office of Proudfoot & Bird, architects, No. 625 Flynn Bldg., Des Moines, Iowa

Bids will be received for the building complete, including heating, plumbing and electric work.

Certified check $5,000, bond 25 per cent of contract price.

The right is reserved to reject any or all bids

FRANK SELLMAN, County Auditor

CONSTRUCTING QUARTERMASTER's Office, Fort Des Moines, Iowa, January 20, 1909.—Sealed proposals, in triplicate, will be received here until 3 p. m., Standard time, February 10, 1909, and then opened, for constructing a steel highway bridge at Fort Des Moines, Iowa, target range. Information furnished on application. Plans and specifications will be sent to intending bidders upon receipt of request accompanied by certified check for $50.00, which will be refunded when the plans and specifications are returned. Envelopes containing proposals should be indorsed, "Proposals for Bridge," and addressed, Constructing Quartermaster, Fort Des Moines, Iowa.

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DODGE—**"Diagrams for Designing Reinforced Concrete Structures."**

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$M = K b d^2$

Is the Formula Wanted

"It means that the resisting moment of the beam is equal to K (a moment factor), multiplied by the breadth of the beam times the square of the depth.

Nothing can be more simple, and when tables containing values of K are available the application is easy.

To obtain the size of a beam change the formula to read:

$$d = \sqrt{\frac{M}{Kb}}$$

in which M = bending moment = resisting moment in inch pounds.

d = depth in inches from top of beam to center of steel reinforcement.

b = breadth in inches.

The moment, M, is found when we know the clear span and load. The breadth, b, we can generally assume at 1/20to 1/24 the span, and K is taken from tables.

Remember that in the following pages the depth of the beam is always the distance from the top to the center of the steel reinforcement. The concrete below the steel is simply there for protection and is not relied upon to add strength to the beam.

Assume the breadth, b, at from 1/20 to 1/24 the span, for the reason that the upper part of the beam is a column and to prevent side bending, or undue stresses at its junction with the slab on top, the length should not exceed 24 times the least thickness. Therefore assume a breadth as above and solve for d. The best shaped beam is one in which b lies between $\frac{1}{2}d$ and $\frac{3}{4}d$. To obtain such a beam may require two or more trials, until designing experience has been gained."

The values of K referred to in the above quotation from "*Reinforced Concrete—A Manual of Practice*" are given in a series of simple tables.

The design of columns, walls, tanks, footings, etc., is treated in an equally simple manner.

There is a notably good discussion of the design of forms, with tables of safe loads for posts and braces, thickness of lagging, spacing of studs, efficiency of nails, bolts and fastenings.

Construction methods and tools are discussed in the same practical and useful manner as are designing methods and data.

Reinforced Concrete, A Manual of Practice

By ERNEST McCULLOUGH

Cloth, 6 x 7 inches; 136 pages; illustrated; $1.50

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How "Concrete Lumber" Has Made Forest Preservation a Farce.

The fast perishing forests of America have been the theme of many a [illegible] lament. "Behold the forests! See the wealth this criminal waste of material [illegible]!" cries the statistician, with the [illegible] almost sniffling in sympathy. Amid all this illogical agitation for forest preservation it is well to turn an eye toward the timber of the future—"concrete lumber," as it has been aptly called. While engineers are well aware that concrete, reinforced with steel, is better than timber and can be used in its place for all kinds of construction, the public lags behind in knowledge and listens seriously to the demands of government foresters for the setting aside of huge domains as "forest reserves." Already, great areas in the mountain states and among the coast counties of Oregon and Washington have been reserved from private ownership, because of the cry for forest preservation. A few years hence the folly of this action will become apparent, for much of the land thus reserved can be used far more profitably for raising fruit than for raising timber. What will open the eyes of the public to this fact? Not argument and oratory, but the silent logic of "concrete lumber" and structures built of Portland cement.

The Pennsylvania Railroad has begun the systematic raising of timber for cross ties, but long before that timber reaches maturity it will be useless for the purpose. Cross ties of reinforced concrete are as certain to replace timber ties as cement sidewalks have replaced those of wood.

Already the farmers of the middle states are "growing" their own fence posts, not by planting acorns, but by pouring a mixture of cement, sand and stone into molds. Hollow telegraph poles of reinforced concrete are common in France, and concrete piles are finding a wider field of usefulness every year.

In Italy barges and scows of reinforced concrete have been used with pronounced success.

Fireproof buildings of concrete are now so numerous as to excite no attention when erected even in the smaller cities, and the day is not far distant when cottages, as well as more pretentious residences, will be built of this stone lumber. It may be that Edison's plan of erecting steel molds and "pouring" a concrete house in a day will be found practicable, although it is likely that other forms of construction will prove more economic for all smaller buildings. The plastering of cement mortar onto expanded metal or wire mesh is quite apt to be the most economic method of building the walls of small houses in some cases, and in others it may be found preferable to erect slabs of real "concrete lumber," made in a central yard and transported to the site ready for use.

Certain it now is that enough has been accomplished with reinforced concrete to prove beyond doubt that forests will soon [illegible] purposes [illegible] and for [illegible].

We have been accustomed to speak of prehistoric ages as belonging to the "stone age," but the real stone age is only just beginning. [illegible] reinforced concrete has [illegible] properties [illegible]. Neither the [illegible] nor the [illegible]. With the growing [illegible] of gravel [illegible] already [illegible] of yesterday will [illegible] of tomorrow, and tomorrow [illegible] will [illegible] new [illegible] for the [illegible] building material formed of [illegible] stone. There are the [illegible] "age of stone" and the modern "age of [illegible]" [illegible], making the new age of reinforced concrete, or "[illegible]," as it has been not inaptly called.

Announcement of the First Meeting of the American Society of Engineering Contractors.

The first meeting of the American Society of Engineering Contractors will take place in March, the exact date to be announced later.

Mr. Gillette has received nearly 1,500 applications for membership in this national society, and would greatly like to see the applications number a full 2,000 before the first meeting takes place. Certainly every contractor in America will find it advantageous to belong to this organization, for it is evident now that it will be the only national society of any considerable magnitude that will protect the interests of contractors. But its membership is not limited to contractors, for it is desired to include engineers as members, also, and, indeed, a very large number of engineers have already applied for membership.

No other society offers a common meeting ground for the representatives of the two parties to a construction contract. However much it may be claimed that the engineer represents neither party, but is a mediator between the two—the owner and the contractor—it is obvious that the engineer is in reality the agent of the party of the first part. By him he is hired, and to him he is accountable. Strive as he will to act in a disinterested manner, the engineer unconsciously leans in favor of his client, the owner. The very specifications that he draws prove his solicitude for the owner's interests—innumerable law cases doubly prove it. Yet there are practically no engineers who do not aim to be fair. As a rule any unfairness on the part of an engineer results from ignorance of the contractor's point of view. It is noticeable that the engineer who has once been a contractor himself is apt to be far more careful and less arbitrary both in the drawing of specifications and in the interpretation of them than

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is the engineer who has never viewed a contract through the spectacles belonging to the party of the second part.

We believe that the proposed society will prove the best possible means of enabling engineers to get the unbiased opinions of contractors as to clauses in specifications, and that, in turn, contractors will understand more clearly what engineers seek to secure by any given wording of a specification. Important as this function of the American Society of Engineering-Contractors will be, the society has many other functions to perform, some of which are outlined in the blank application for membership in the society which will be found on one of the advertising pages of this journal.

Is It Advisable for Engineers to Publish Their Estimates of the Cost of Projected Work?

On the Barge Canal work in New York State it is the practice to publish the engineer's estimate of the cost of each proposed contract. The estimate is made in detail and forms a part of the specifications, for one object of the estimate is to provide a method of preventing unbalanced bids. No bid is accepted if it exceeds the engineer's estimate of the total cost by 10 per cent. Any bid may be rejected if any one of the unit bidding prices exceeds the engineer's estimated unit price by 20 per cent.

While this last named practice is of questionable value as compared with other methods of preventing unbalanced bids, we shall not discuss it at present. The question that we wish to put before our readers is the question that heads this article.

Those who are opposed to publishing the engineer's estimate have a very strong argument. They assert that many an ignorant or incompetent contractor will bid upon work whose estimated cost is made public, acting upon the assumption that, if the engineer has made a careful estimate of cost, there can be no chance of loss by bidding slightly below his estimate. Hence contractors who really do possess knowledge of their own are likely to be underbid by contractors who have no knowledge save that secured from the engineer's estimate.

We have known this to happen a great many times in the past, but we must not forget that general knowledge of actual costs has greatly increased within the last five years and that, as a consequence, contractors are becoming much more cautious than they used to be in the matter of accepting engineer's estimates as a safe criterion for their own bidding prices.

Eleven years ago (and indeed, nine years ago) there was not a single book or article in the English language giving an example of the detailed cost of a macadam road. The writer was at that time preparing to bid on the first macadam road to be built under the direction of the State Engineer of New York. The State Engineer's estimate was known to the writer as well as to other contractors, and the most important item, "macadam rolled in place," had been estimated by the State Engineer at $1.00 per cu. yd.! No such erroneous estimate would be made by any engineer today, and, if made, it would deceive no contractor who had wit enough to avail himself of published data. The times have changed. Costs have become the subject of scientific investigation and analysis.

The very differences between recorded costs are making contractors cautious, and will make them more and more cautious in bidding upon large jobs of a class in which they have had small experience.

Only a few days ago (in our issue of Jan. 13) we published an article by a well known contractor for reinforced concrete work, Mr. Leonard C. Wason, giving summaries of his own costs of reinforced concrete buildings, etc. Mr. Wason stated that one of his objects in making public his costs was to educate inexperienced contractors, so that bids on such work would cease to be so ruinously low as to prevent his own firm from securing contracts at a fair profit.

When the writer first published his records of the cost of road construction he had in mind much the same object as that which Mr. Wason has given, although subsequently he became convinced that publication of costs is justified on the much broader and less selfish policy of assisting others, for the sake of raising the whole level of economic efficiency. Secretiveness is the product of ignorance, and the Chinaman is its trademark. Secretiveness as to actual costs has been the cause of innumerable underestimates made by engineers and has resulted in the disrepute that engineers still suffer in the eyes of business men who hark back to bitter experiences of a decade or more ago. Even today great surprise is expressed when a large construction job is finished within the engineer's estimate. The writer knows many bankers whose invariable practice is to add 50 per cent or more to engineers' estimates of projected railways which they intend to finance. Who can measure the incalculable harm that such opinions as to engineers' estimates have caused and still cause when a really good railway project is presented with *accurate* estimates of cost?

In passing let us emphasize the fact that while the cost of the great Panama Canal has been underestimated, it has been less the fault of the estimators than of the builders. The unit prices originally assumed were amply large enough, but the estimators had never dreamed that the actual construction would be done by the notoriously inefficient day labor system. Nevertheless, the general public will chalk down one more great discredit mark opposite the words "engineers' estimates," and this is not the least of the ills that flow from the doing of this work with government labor forces.

Publicity of any sort is likely to be followed by some instances of regrettable inconvenience or positive loss to some one, but a general policy of publicity is one of the modern tenets of political economy whose soundness few will question. As a corallary to this proposition it is clear that the publication of engineers' estimates of the cost of any projected work will work for good in the long run. At first there will be some contractors who will be fools enough to bid just a shade under the estimates, without any knowledge of their own to guide them. This will be a passing phenomenon.

Publication of engineers' estimates will have many decided advantages: First, it will show prospective bidders not only the number of units of work to be done but the engineer's estimate of the character of each unit as regards its cost. A yard of earth in some places is worth 15 cts. to excavate and transport, in other places it is worth 75 cts. When the estimated prices are given the contract has at once a bird's eye view of probable character of the work, from which he can decide whether it warrants his visiting the site to prepare a bid. Second, the engineer's estimate serves to check the contractor's own figures, and frequently leads him to a more careful examination of conditions to ascertain why the engineer's estimate was so high or so low. Third, the engineer's estimate enables a contractor to discuss with the engineer his reasons for certain estimated prices. From such a discussion both parties are likely to profit. Fourth, the publication of such estimates in the columns of technical journals will lead to discussions among engineers and contractors, and thus prove it a fruitful source of arousing further interest in the vital subject of cost analysis and in spreading knowledge of costs.

It would be well if engineers were to give a printed description of conditions, accompanying their specifications and estimated cost. This description would often lead contractors to go over the ground where otherwise they would not visit the site of the work at all, which is particularly true of work in places not easily accessible to many contractors.

We shall welcome further discussion of this subject in the columns of this paper, particularly from engineers who have strong reasons for or against the publication of their estimates of cost.

The production of petroleum in the United States in 1908, according to a preliminary estimate made by David T. Day, of the United States Geological Survey, amounted to between 175 and 180 million barrels, an increase between 5 and 9 per cent as compared with the production of 166 million barrels in 1907. The total value of the product showed an even greater proportionate gain, for the price of oil increased in California and remained steady in other fields except the Gulf. The increases are attributed to steady growth in Illinois and California, though neither field showed phenomenal development.

Concrete and Reinforced Concrete Section

Note:—This section is devoted to methods and cost of constructing concrete and reinforced concrete structures. It will cover the selection, testing and proportioning of concrete materials; laboratory tests of concrete; concrete mixing, transportation and placing; fabrication and placing of reinforcement, and form construction and erection. It will also contain articles on new and interesting developments in the design of reinforced concrete.

The Construction and Cost of Small Concrete Houses.*

BY C. R. KNAPP.†

(Comparatively few cost data on concrete house construction are to be found in engineering literature, yet concrete houses of both block and monolithic construction are being built in increasing numbers. The cost data given in this paper, therefore, though very general, are of considerable interest. They indicate the surprising economy of concrete as compared with other common house building materials.—Editors.)

Brick construction will cost for a 13-in. wall from 36 cts. to 50 cts. per sq. ft., and for a 9 in. wall from 25 cts. to 35 cts. per sq. ft. To these figures must be added, for the finished wall, cost of furring, lathing and two brown or scratch coats of plaster and the white coat.

Hollow tile construction, which has an advantage over brick by reason of its air space, averages about the cost of brick or a trifle under.

The cost of block construction is from 18 cts. to 35 cts. per sq. ft. of wall having a thickness of 8 to 12 ins. inclusive. For the finished wall, add the cost of the white finish coat which is put directly on the concrete, thus saving the cost of furring, lathing and the two brown or scratch coats of plaster.

A plain or reinforced concrete wall is much stronger in every feature than a brick wall. It is, therefore, not necessary to make the concrete wall as thick, in order to get the proper factor of safety. The Philadelphia Building Laws take cognizance of this fact by requiring in concrete only two-thirds of the thickness called for in brick.

For house construction, I would advise two 4-in. walls, with a 4-in. air space. The two walls should be tied with metal ties in concrete webs. This gives a wall of full strength, saves materials, gives an absolutely damp-proof house, and all the benefits derived from the 4-in. air space. It also saves the furring, lathing and two brown coats of plaster, the finishing coat being plaster on the concrete. This wall will cost from 15 cts. to 25 cts. per sq. ft., plus the finish coat.

Another method is to use a 6-in. wall, which is strong enough for any two-story house, with furring, lathing or "Hy rib" metal sheathing on the inside, which gives enough air space to keep any dampness from coming through. Plaster in the regular way with two brown coats and one finish coat. This will cost from 11 cts. to 16 cts. per sq. ft. for the concrete, plus the furring, lathing and plaster. These prices are equal to $6 to $10 per cu. yd. of concrete.

Concrete partitions, 2 ins. thick, reliable in every way, can be put up for 16 cts. to 20 cts. per sq. ft. Floors, by using concrete in connection with hollow tile, can be placed for about 25 per cent to 40 per cent more than the wooden-joist construction we are now using. A concrete roof costs but a few dollars in excess of what we are paying for the best wooden shingles. During the past summer the writer constructed a stable for Mr. Robert E. Griffith at Haverford, Pa. The outer walls and partition walls were 6 ins. thick. They were all carried up at the same time as a unit. To do this we used two rounds of 12-in. boards inside and out, fastened with the Dietrich clamps. The results obtained were quick construction, which means a saving of labor, economical use of lumber and a minimum cost which was in this case $1,580, as compared with a bid for brick of over $2,500 and for frame of $2,000. The lumber used for forms and scaffolding was utilized in the carpenter work, thus there was no waste.

Where the form is a part of the builder's permanent equipment, to be taken from job to job, I would suggest units 8 ft. long by 3 ft. wide. When two rounds of 12-in. board units are used it often happens that the placing of concrete is delayed owing to the men changing forms and not being able to keep ahead of the mixing. By using two rounds of the 8x3-ft. units, which are easy to handle and cost no more than the one-board unit, two men changing forms can keep ahead of six men mixing and placing. This gives the concrete a longer time to set before the forms are taken off.

If care is taken in placing the concrete there are no surface voids and it will leave a smooth wall for any of the many different finishing methods we may wish to apply. The method giving the best result for the least work is to thoroughly wet the walls and then apply with a brush a thin 1-2 mortar, rubbed in well with a carborundum stone. This produces a lather on the surface, removes all board marks and fills the pores. Before it is dry go over the wall with a brush dipped in water. The result is a hard smooth even surface uniform in color. A great deal can be done in the same way.

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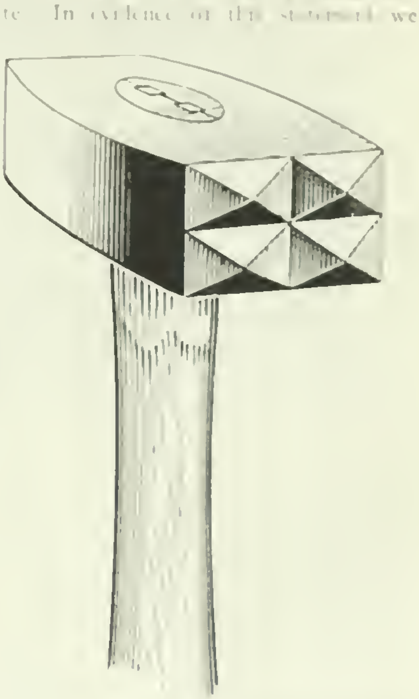
*Extracts from a paper presented to the National Association of Cement Users, Cleveland Convention, Jan. 13 to 16, 1909.

†Concrete Contractor, Philadelphia, Pa.

A Hammer For Finishing Concrete Surfaces.

Concrete surfaces may be finished by tooling by any of the methods and in any of the styles employed by stone cutters for masonry stones. Ordinarily, however, all that is required is a style of tooling that will remove the cement skin and the form marks. Very simple tools and an ordinary quality of labor will produce such tooling successfully, and at a reasonable cost compared with other methods of finishing concrete. In evidence of this statement we show by the accompanying cut a hammer for tooling concrete and give some costs of work done with it.



Hammer for Finishing Concrete Surfaces.

The hammer illustrated is a design worked out by Mr. Howard B. Green, Manager of Sales, Whitehall Portland Cement Co., Philadelphia, Pa. It is, we understand, not patented and is free to any one to make and use. A good blacksmith should be able to make the hammer at small cost. It is operated by striking a square face blow, and any workman of ordinary intelligence can learn to operate it in a few hours. This hammer has been used by Mr. Green in finishing a concrete residence built for himself. One man was able with it to tool from 100 to 200 sq. ft. per 10 hours. Mr. Green states that the cost of a good quality of tooling, exclusive of scaffolding, is from 2 cts. to 3 cts. per sq. ft.

During 1908 almost $7,500,000 worth of construction work was done on the New York State Barge Canal.

New Reinforced Concrete Board Mill of the Androscoggin Pulp Co., South Windham.

The adaptability of reinforced concrete and its increasing use in the construction of paper and pulp mill plants is clearly shown in the case of the new board mill of the Androscoggin Pulp Co., at South Windham, Maine. The selection of concrete in preference to any other building material for such structures rests on the fact that it is thoroughly fireproof, that the maintenance charges are very low and that buildings can be erected with great rapidity and put into operation with the minimum loss of time. A well-built concrete mill will usually cost from 10 to 15 per cent more than one of the ordinary construction capable of supporting the same floor and column loads, but the added expense may be readily offset by the advantages which have just been mentioned.

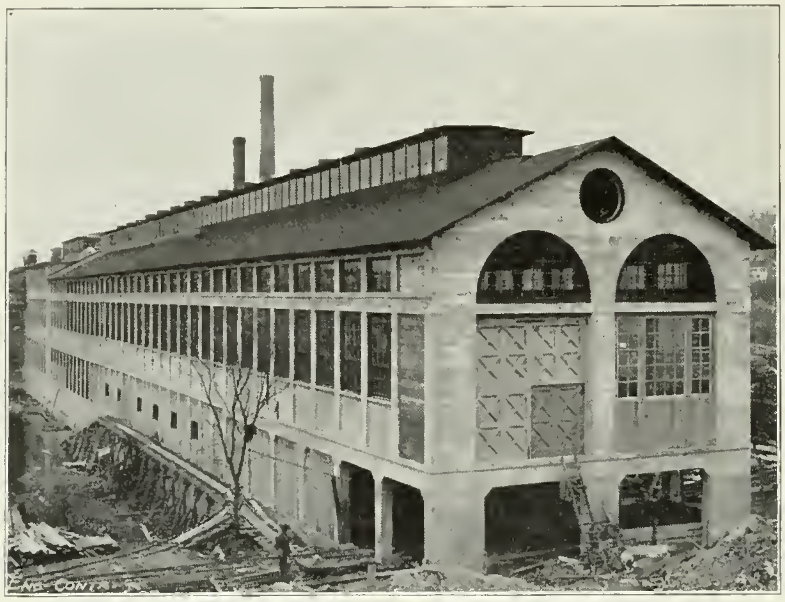


Fig. 1—Reinforced Concrete Mill, Androscoggin Pulp Co.

The structures illustrated comprise a machine room and an engine room, the boilers being located in a separate building. Reinforced concrete is exclusively used for floors and walls, and for the roof of the beater building. The roof of the machine building and all the monitors are of wooden construction. Generous lighting is provided through extensive window area in the walls and monitors.

The total length of the main building, Fig. 1, is 376 ft., the average height being about 50 ft. The machine room at the east end is 303 ft. long and 40 ft. wide; adjoining this at the westerly end is the beater building, 73 ft. long by 77 ft. wide. The former is one story in height with basement, while the latter is of two stories, also with basement.

The entire equipment of the new building is driven by engines installed in the one-story power house, 39 ft. by 48 ft., on the northeast side, filling in the corner between the beater and machine buildings.

A feature of the machine building is the cantilever support employed for the board machine, Figs. 2 and 3. The side beams upon which this machine rests are 6 ft. 6 ins. in depth by 21 ins. in thickness and are spaced 9 ft. 11 ins. apart. These beams are in turn supported on a single row of columns spaced 24 ft. on centers. Spread caps 42 ins. thick on the top of each column transmit the pressure of the side beams onto the columns. The latter are octagonal in section, 3½ ft. thick, face to face, and are supported on concrete piers 4 ft. in diameter, carried down to ledge. The vertical reinforcement of the columns consists of four ⅞-in. bars placed close to those faces which are subject to the greatest flexure and one ⅜-in. rod in the center of each of the remaining faces. These bars run well into the cantilever cap. Hoops of ½-in. rods spaced 3¾ ins. on centers embrace the vertical reinforcement and stiffen it locally. The cap is reinforced by diagonal bracing of ¾-in. bars hooked over the column reinforcement. The concrete for the column is composed of 1 part cement, 1½ parts sand and 3 parts of 1-in. broken stone. The cantilever cap beams are of 1-2-4 concrete. The space enclosed beneath the machine is 4 ft. 6 in. in depth below the floor line. The wall columns are 12 x 14 in. in section and spaced 8 ft. on centers except those at finishing end of the machine building, these being 12 ft. on centers. The short transverse floor beams for the basement and first floors, including the second floor of the beater building, which are in all instances integral with the floors, project 8½ ins. below, and are spaced 2 ft. on centers. The basement floor, the first floor in the beater building, and the finishing end of the machine building are 3½ ins. thick. In the remaining portion of the machine building and the second story of the beater building the floors are but 3 ins. thick. The first floor in the former building is pitched 1½ ins. downward toward the middle.

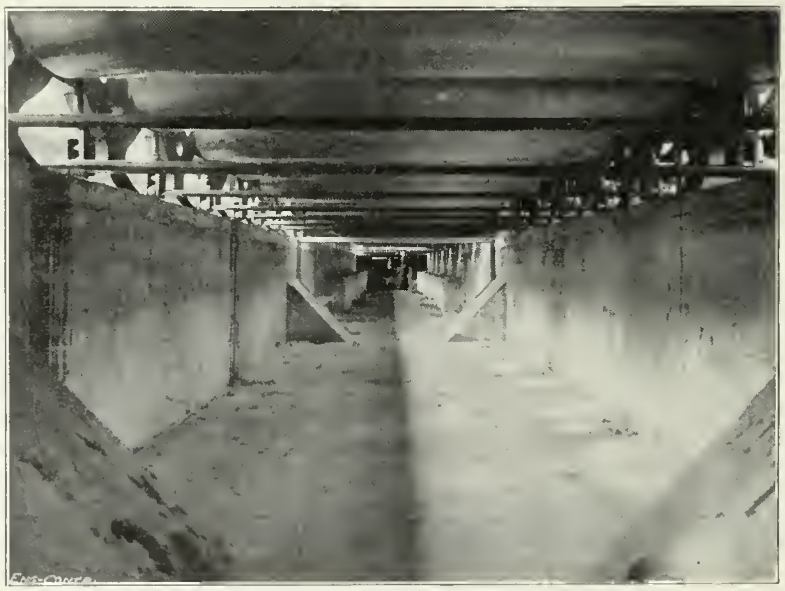


Fig. 2—Pit Under Board Machine.

The piers under the body of the building are of circular section, 4 ft. in diameter, while those under the walls are of similar section of 3 ft. in diameter. These are spaced 24 ft. on centers longitudinally and 19 ft. 8¾ ins., transversely. At the finishing end of the machine building are two side wall foundations braced by a transverse wall at the west end, all 3 ft. thick and carried down to ledge.

The roof over the beater building is of reinforced concrete 3 ins. thick, supported on reinforced concrete beams spaced 8 ft. apart. That covering the machine building is of plank 1¾ ins. thick, pitched 6 ins. per foot, and supported by steel trusses resting on the wall columns.

The work was designed by T. W. Jones, Milton, N. H., and the contractors were the Aberthaw Construction Co., Boston, Mass.

The Cost of Cement Block Walls Compared with the Cost of Brick Walls.*

BY J. A. SMITH.†

Coming to the subject of cost data on cement blocks, I have prepared such data, showing the comparative costs of cement blocks and common brick laid in the wall. In drawing up this statement of costs, however, I have used faced blocks entirely throughout my computation, and have compared faced blocks with common brick in the figures given.

I have also prepared a comparative statement of faced cement blocks and facing brick in conjunction with ordinary brick laid in the wall, as well as a comparative cost of cement blocks and monolithic construction. In getting up this table I have had an eye to the absolute conservatism that should surround such a table in figuring such costs, and I think you will find that I have tried to treat this subject in a thoroughly conservative way. If I have erred at all, it has been in placing the cost of blocks too high, and the cost of brick too low, but I have done this with the idea of being ultra conservative so far as blocks are concerned. Furthermore, I have made a distinction in these cost data, as between the small sized plant, operating with two or three men, mixing by hand, and buying materials in small quantities; and, the thoroughly and perfectly equipped plant where the materials are elevated, pneumatic or power tamping used, materials bought in quantity, cars and track used for the transportation of the block, and a greater number of blocks turned out per day. A well thought out, complete plant, properly equipped, will, of course, reduce the cost of the stone turned out materially.

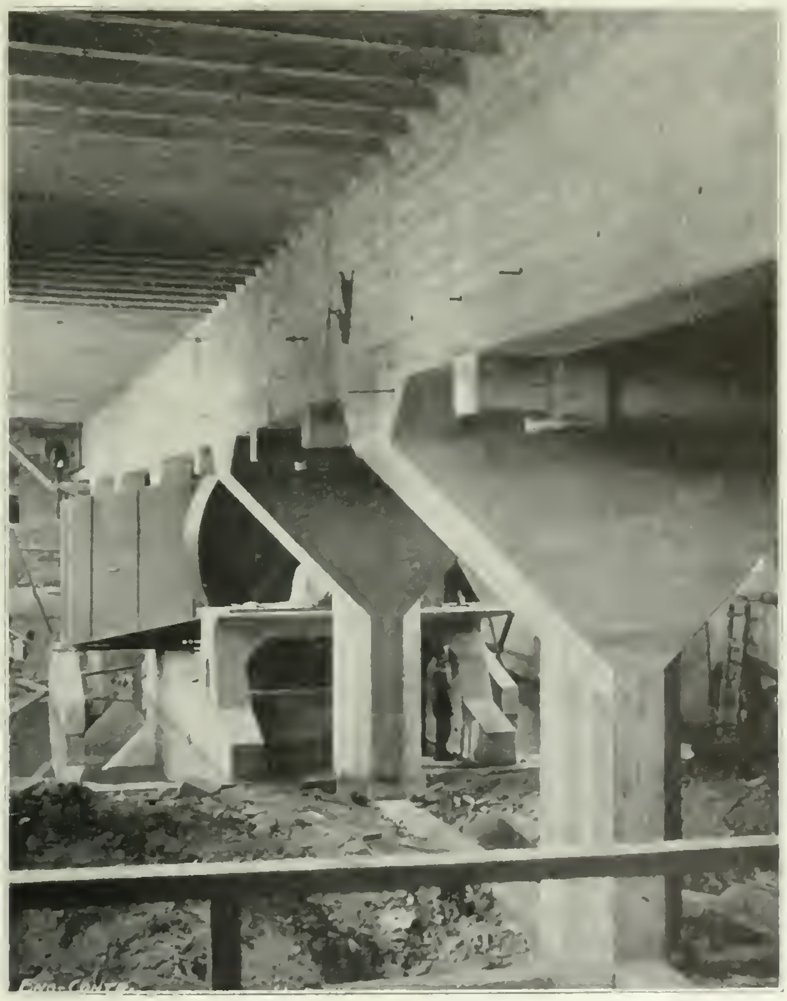


Fig. 3—Columns Supporting Pit Under Board Machine, Androscoggin Pulp Co.

I call your attention to the following cost data as above outlined, proportions of 1—3—4; facing ½ in. thick of 1 cement—2 sand.

100—8x8x16-in blocks require

1.05 cu yds gravel, at $1.00	$1.05
.79 yds sand, at $1.00	.79
2.02 bbls cement, at $1.50	3.04
Labor, at .02¾ cts per blk	2.75
	$7.63

100—8x10x16-in blocks require

1.40 cu yds gravel, at $1.00	$1.40
1.06 cu yds sand, at $1.00	1.06
2.62 bbls cement, at $1.50	3.94
Labor, at .03 cts per blk	3.00
	$9.40

100—8x12x16-in blocks require

1.68 cu yds gravel, at $1.00	$1.68
1.27 cu yds sand, at $1.00	1.27
3.08 bbls cement, at $1.50	4.62
Labor, at .03¼ cts per blk	3.25
	$10.82

100—8x8x24-in blocks require

1.62 cu yds. gravel, at $1.00	$1.62
1.23 cu yds. sand, at $1.00	1.23
3.12 bbls cement, at $1.50	4.68
Labor, at .04 cts per blk	4.00
	$11.53

100—8x10x24-in blocks require

2.02 cu yds gravel, at $1.00	2.02
1.53 cu yds at $1.00	1.53
3.80 bbls cement at $1.50	5.70
Labor, at .04¼ cts per blk	4.25
	13.50

100—8x12x24-in blocks require

2.43 cu yds gravel at $1.00	2.43
1.82 cu yds sand, at $1.00	1.82
4.46 bbls cement, at $1.50	6.70
Labor, at 4½ cts per blk	4.50
Total cost of 100 blocks	$15.45

100—8x8x16-in blocks will displace from 1,333 to 1,422 brick

1,333 brick laid in wall at $14 per M. cost		$18.67
100—8x8x16-in faced blocks cost	$7.63	
These selling at 4 cts profit per block, cost	$11.63	
Laying in walls costs	3.00	
	$14.63	$14.63
Saving on every 100 blocks		$4.04

100—8x12x16 in blocks will displace from 2,000 to 2,133 brick

2,000 brick laid in wall at $14 per M., costs		$28.00
100—8x12x16 in faced block cost	$10.82	
Allowing 4 cts profit per block, cost	$14.82	
Laying costs	4.00	
Total cost in wall		$18.82
Saving on every 100 blocks		$9.18

100—8x8x24-in blocks will displace from 2,000 to 2,133 brick

2,000 brick laid in wall at $14 per M		$28.00
100—8x8x24 in blocks cost	$11.53	
Allowing 5 cts profit per block cost	$16.53	
Laying costs	5.00	
Total cost in wall		$21.53
Saving on every 100 blocks		$6.47

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*Extracted from a paper presented to the National Association of Cement Users, Cleveland Convention, Jan. 13-16, 1909.

†South Bend, Ind.

100—8x12x24-in. blocks will displace from 3,000 to 3,200 brick.

3,000 brick laid in wall at $14 per M., cost		$42.00
100—8x12x24-in. blocks cost	$15.50	
Allowing 6 cts. profit per block cost	$21.50	
Laying at 7 cts. per block	7.00	
Total cost in wall		$28.50
Saving on every 100 blocks		$13.50

A high grade of facing brick, costing $21 per thousand, will cost, laid in the wall, $48 per thousand. We have assumed common brick at $14 per thousand.

An 8-in. brick wall faced with pressed brick as per the above, and equivalent to 100—8x8x16-in. blocks will require:

667 pressed brick at $48 per M.	$32.00
667 common brick at $14 per M.	9.33
Total	$41.33
100—8x8x16-in. faced blocks laid in the wall costs	$12.93
Saving on every 100 blocks	$28.40

A 12-in. brick wall, faced as above, and equivalent to 100—8x12x16-in. blocks will require:

667 pressed brick at $48 per M.	$32.00	
1,333 common brick at $14 per M.	18.66	
Total		$50.66
100—8x12x16-in. blocks laid in the wall costs		16.55
Saving on every 100 blocks		$34.11

The above figures allow 4 cts. profit per block to the manufacturer. In a case like this the manufacturer would figure on a higher profit, as he is always sure of getting the job when competing with pressed brick.

An 8-in. brick wall, faced with pressed brick and equivalent to 100—8x8x24-in. blocks will require:

1,000 pressed brick at $48 per M.	$48.00	
1,000 common brick at $14 per M.	14.00	
Total		$62.00
100—8x8x24-in. blocks laid in the wall cost		19.00
Saving on every 100 blocks		$43.00

These figures allow the manufacturer 5 cts. profit per block.

A 12-in. hrick wall, faced with pressed brick and equivalent to 100—8x12x24-in. blocks will require:

1,000 pressed brick at $48 per M.	$48.00	
2,000 common brick at $11 per M.	28.00	
Total		$76.00
100—8x12x24-in. blocks laid in the wall cost		27.65
Saving on every 100 blocks		$48.35

The above figures allow 7 cts. per block profit to the manufacturer.

As stated above, when competing with pressed brick and cut stone, the manufacturer will usually charge a higher price for his blocks, as he will have a greater leeway.

The above computation on brick is figured upon the least displacement 100 blocks will displace in the wall; 1,333 brick is figured on a basis of 22½ brick to the square foot of 12-in. wall, three brick thick, or 15 brick per square foot of 8-in. wall. The same is true in every other computation I have made, as I have taken the least displacement possible on which to base my figures so that the results cannot be questioned from a standpoint of favoritism to cement blocks. Furthermore, all the above is based on costs shown in small sized plants, operating with two to three men, mixing by hand, and buying materials in small quantities.

The labor costs include all fractional and window jamb blocks. Furthermore, the costs shown are faced cement blocks against common brick. Where pneumatic, or power tamping, is used, materials are bought in quantity and a greater number of blocks turned out, the cost can be cut down considerably, and will more nearly approach the following:

100—8x8x16-in. blocks will require:

1.05 cu. yds. gravel, at	$ .80	$ .84
.79 cu. yds. sand, at	.80	.63
2.02 bbls. cement, at	1.30	2.63
Labor		1.83
		$5.93

This assumes a reduction in labor of 33⅓ per cent. Figuring on the above basis the other sizes will cost as follows:

100—8x10x16-in. faced blocks will cost	$ 7.46
100—8x12x16-in. faced blocks will cost	8.55
100—8x8x24-in. faced blocks will cost	9.00
100—8x10x24-in. faced blocks will cost	10.63
100—8x12x24-in. faced blocks will cost	12.21

100—8x8x16-in. blocks, with 4 cts. profit per block, can sell at	9.93
Laying in wall will cost	3.00
	$12.93
Equivalent brick (1,333) laid in wall at $14 per M.	$18.60
Saving on every 100 blocks	$ 5.67
100—8x12x16-in. blocks, with 4 cts. profit cost	$12.55
Laying costs	4.00
	$16.55
Equivalent brick (2,000) laid in wall at $14 per M.	$28.00
Saving on every 100 blocks	$11.45
100—8x8x24-in. blocks, with 5c profit per block, cost	$14.00
Laying costs	5.00
Total cost in wall	$19.00
Equivalent brick (2,000) laid in wall at $14 per M.	$28.00
Savings on every 100 blocks	$ 9.00
100—8x12x24-in. blocks, with 7 cts. profit per block, costs	$20.65
Laying costs	7.00
Total cost 100 blocks in wall	$27.65
Equivalent brick (3,000) laid in wall at $14 per M.	$42.00
Saving on every 100 blocks	$14.35

An 8-in. monolithic wall, 1—3—5, figured on a basis of $1 per cu. yd. for gravel and sand, and $1.50 per barrel of cement, will cost about $7.12 per cu. yd. under very fair conditions.

100—8x8x16-in. faced blocks cost	$ 5.93
Laying costs	3.00
Cost in wall	$ 8.93
Cost per cu. yd.	4.09
Saving per cu. yd. in favor of blocks.	3.03

A 10-in. monolithic wall will cost $6.52 per cu. yd.

100—8x10x16-in. faced blocks cost	$ 7.46
Laying costs	3.50
Cost in the wall	$10.96
Cost per cu. yd	3.99
Saving per cu. yd. in favor of blocks.	2.53

A monolithic 12-in. wall will cost $5.02 per cu. yd.

100—8x12x16-in. faced blocks cost	$ 8.55
Laying costs	4.00
Cost in the wall	$12.55
Cost per cu. yd. of wall	$ 3.82
Saving per cu. yd. in favor of blocks.	1.20
100—8x8x24-in. faced blocks cost	9.00
Laying costs	5.00
Cost in the wall	$14.00
Cost per cu. yd. of wall	4.27
Saving per cu. yd. in favor of blocks.	2.85
100—8x10x24-in. faced blocks cost	$10.63
Laying costs	6.00
Cost in wall	$16.63
Cost per cu. yd. of wall	4.05
Saving per cu. yd. in favor of blocks.	2.47
100—8x12x24-in. faced blocks cost	$12.21
Laying costs	7.00
Cost in the wall	$19.21
Cost per cu. yd. of wall	3.89
Saving per cu. yd. in favor of blocks.	1.13

I desire to call your attention to the fact that the above figures are based, in the one case, on cement blocks in a finished wall, while in the case of the monolithic wall, the superficial surfaces still have to be taken care of, which adds, naturally, to the cost, and which is not included in the above figures. These figures, therefore, show how much cheaper concrete block walls are than the solid monolithic walls, and the above figures are on the plainest kind of monolithic work, and do not take into account any reinforcing.

Cost of White Facing for Cement Blocks.—The cost of white cement for white facing is nearly 2¼ cts. per block, 8x8x16 ins., and should be figured at 3⅜ cts. per block 8x8x24 ins. on the basis of $5 per barrel for white cement.

White sand will cost about 1 ct. for the 16-in. blocks and 1½ cts. for the 24-in. blocks. This is figured on a facing of 1 cement to 2 sand, facing to be ½ in. thick.

Before I leave the subject of costs in cement block construction I desire to call particular attention to the antagonism to the use of concrete blocks by bricklayers and masons generally. It is a conceded fact, I believe, that cement blocks can be laid in the wall nearly one-half as fast again as the same number of brick. There is undoubtedly a distinct and determined effort on the part of bricklayers and masons to prevent the use of cement blocks wherever it is possible to discard them, and this association should take this matter in hand and endeavor to have passed a regulating scale for the laying of cement blocks, that would permit equitable and fair treatment. The bricklayer is paid by the hour, and it seems to me it should not matter to him whether he lays blocks or brick. But he does—and I am constrained to believe that the genesis of the bricklayer's objection lies in the brick manufacturer, who exerts his antagonism through the tentacles of the Bricklayers' Union, or Association.

I may say from personal knowledge, that it is a difficult matter to have cement blocks laid in many cities; they won't touch them. They frequently excuse themselves on the ground that it cuts down their wages. This explanation is, however, futile, in view of the fact that these workmen are paid by the hour, irrespective of the number of blocks, or brick, laid, and I think the time is propitious for taking up this subject in an intelligent, aggressive way, and arranging this matter upon a basis that shall be fair alike to the employer and the employed.

The submission of the figures I have quoted above, and the showing in reduced costs of the complete, thoroughly equipped plant, brings up the question of the proper equipment of a complete and up-to-date plant, and the profit to be made by conducting such an establishment. My experience has proven that this business, properly conducted, with a plant properly equipped, is a very profitable one indeed. As a matter of fact, I know of no business today in which a man can engage with such assurance of success, and with so small an investment to begin with, as in the cement block business.

I desire to call your attention however to the fact that it is just as necessary to exercise good judgment and common sense in the conduct of this business as it is in any other. As a matter of fact, the great lack of ordinary business judgment and ordinary business method has been one of the great causes in the past for many of the failures which have taken place.

A good, complete plant should be well laid out, with sufficient buildings and sufficient yard room in which to conduct the business satisfactorily and economically. Elevators should be used to elevate the materials above the mixing machines; mixers are essentially necessary; power tampers should be installed, and I believe the future will demonstrate that cement blocks should be cured by high pressure steam. I believe the tests which were carried out at St. Louis, and which have been conducted for some time past, have conclusively proven that there is a method of steam curing, under pressure, that is safe and sound, and that this method produces results that are really astonishing.

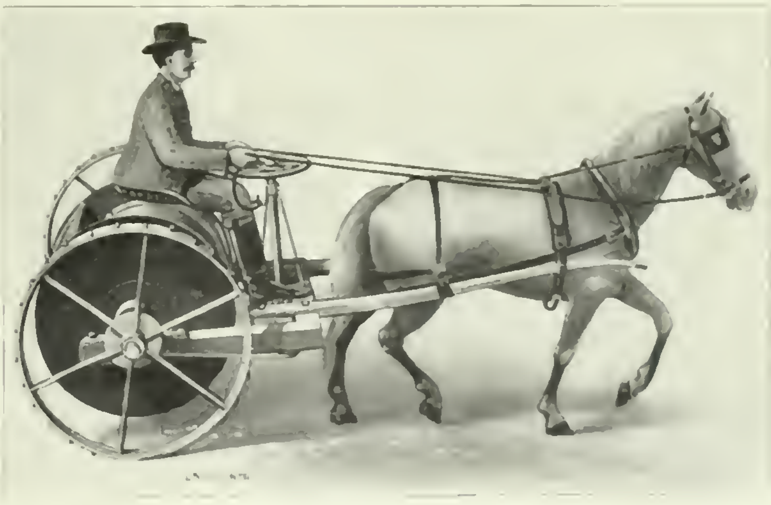
I, therefore, wish to say, in closing this paper, that the future for cement blocks is most promising. Indeed, the use to which this material will be put will be of the widest character, and it is difficult to exaggerate the importance of cement blocks in future construction work. Their manufacture is a business in which great profit can be made; it is a business which is worthy of the hightest craft and care, and if you will perform your share in turning out blocks of acceptable design to the architect, blocks of good appearance, well cured and which will be impervious to moisture, I say to you, you will one day reap the harvest you have worthily prepared.

Spain lead in 1908 in the production of quick silver, a total of [illegible] tons being produced by that country.

A New Traction Concrete Mixer.

On many classes of work a mixer which will transport and mix concrete in one operation has an important field of utility. The mixer shown in the accompanying cut is of this kind. It consists of a mixing drum mounted on traction wheels, and provided with a frame, tongue and seat for operation by a horse and driver. The revolution of the traction wheels as the vehicle is hauled along rotates the drum and mixes the concrete, the arrangement is such that the batch is turned twice for each revolution of the traction wheels.

With this traction mixer the engine and wheel-barrows are dispensed with and a horse and boy driver are used. All one needs to do is to drive up to the sand or stone pile, load up the mixer with sand and cement and add water, drive about 25 yards to the work, and the contents of the mixer will be mixed better, it is stated, than if turned over six times on the board with hoe and shovel. By the time one has driven 25 yards he should be at the point where he wants the concrete. The man who spreads the concrete pulls the drum backwards by means of a lever provided for this purpose, and discharges the contents of the drum. The boy drives up to the stone or sand pile again to reload the machine. The cost of spreading the concrete is reduced as the concrete mixture is dumped in a pile 18 ins. long and about 6 ins. high, leaving very little work for the man who spreads the concrete.



Eurrell Traction Concrete Mixer.

With two men to load the mixer, one to spread the concrete, and a boy to drive the horse, it is stated that from 300 to 400 sq. yds. of concrete, 6 ins. thick, can be put in in 10 hours.

The mixer can also be used for other work by making a platform the same as for mixing with a hoe or shovel. Drive up to the board, unload, and wheel or shovel the concrete to where it is wanted. Even with this method it is said the mixer will handle material cheaper than any other method.

The makers state that they are now making plans to place this traction mixer on a car propelled by a gasoline engine, so as to mix material at the same time it is carried to the job, for use in laying foundations for railroad ties for electric or steam roads. The proposed plan is to run the mixer alongside a flat car and load the sand or gravel into the mixer and carry it from the flat car to where it is wanted, and mix it while in transit.

This mixer is made by the Burrell Manufacturing Co., of Bradley, Ill.

Coming Conventions of Interest to Cement Users.

The following associations of cement users will hold conventions during the next few weeks for the discussion of subjects relating to the manufacture and use of cement products and for the exhibition of machinery and tools for concrete work:

Iowa Association of Cement Users.—Convention at Des Moines, Ia., on Feb. 2, 3 and 4, 1909. Convention hall at the Savery Hotel, Locust and Fourth streets; exhibition hall at the Curzon Building on Court avenue, between Second and Third streets. Sessions will be held on the afternoon of Feb. 2, morning and afternoon of Feb. 3, and morning of Feb. 4. Exhibits should be addressed to Exhibition Hall, Curzon Building, Des Moines, Ia. Blank applications for exhibition space may be secured from Secretary, Ira A. Williams, Ames, Ia., to whom remittance and requests for information should be addressed.

Nebraska Cement Users Associotion.—Convention at Lincoln, Neb., on Feb. 10, 11 and 12, 1909. Convention hall at the Lindell Hotel, 13th and M streets; exhibition hall, Auditorium, 13th and M streets. The exhibition will be restricted to articles not for sale; no patented articles will be allowed among the exhibits; no fee will be charged for exhibition space. Secretary I. E. Walenpaugh, Lindell Hotel, Lincoln, Neb., should be addressed for exhibition blanks and information.

Cement Products Exhibition Co.—The exhibition will be held at the Coliseum, Chicago, Ill., Feb. 18 to 24, 1909. No technical meetings are held, the occasion being solely an exhibition of cement machinery, tools and products. This is perhaps the largest exhibition of the kind held in the United States and the visitor is certain of seeing examples of practically all classes of cement machinery and cement products. Address Cement Products Exhibition Co., 115 Adams St., Chicago, Ill.

Northwestern Cement Products Association.—Convention at Minneapolis, Minn., March 2 and 3, 1909. Convention and exhibition halls at the Armory. Secretary, J. C. Van Doorn, Minneapolis, Minn.

Methods and Cost of Constructing a Reinforced Concrete and Highway Bridge.*

The bridge had a clear span of 30 ft. and an 80-ft. roadway. The arch ring was 8 ins. thick at the crown and 12 ins. thick at skewbacks, with a rise of approximately 6 ft. It rested on 12-in. abutment walls with centerposts and 21-in. footing slabs. The spandrel walls were 12 ins. thick and reached well beyond the abutment walls on each side, the free ends having inside counterforts. The height of the abutment walls from skewback to water level was 12 ft. These walls were continued beyond the faces of the spandrel walls by wing walls, which held the slopes of the deep fill from the channel. This fill reached to a height of 4 ft. above the crown of the arches. All walls were founded on piles. There were 872 cu. yds. of concrete in the structure. The general design was made by City Engineer M. P. Blair, St. Boniface, Manitoba, where the bridge was built and the reinforcement was designed and supplied by Clarence W. Noble, Winnipeg, Manitoba. The reinforcement was high carbon square twisted steel bars. The work was done by day labor by the city engineer and cost as follows:

Foundations.	Total Cost.
5,336 cu. yds. excavation at 38.2 cts.	$2,034.63
6,060 lin. ft. piling at 14.7 cts.	893.85
Driving piles at 15½ cts. per lin. ft.**	939.30
Total	$3,867.78

Concrete Materials.	Total.	Per Cu.Yd.
1,446 bbls. cement at $2.45	$3,543	$4.063
872 cu. yds. aggregate f. o. b. cars at $1	872	1.000
Lumber for forms, etc. (1/3 of $1,491)	497	0.570
Reinforcing bars	1,418	1.626
Totals	$6,330	$7.259
Labor.		
Labor on forms 7	$ 652	$0.74
Placing reinforcement	129	0.148
Hauling aggregates	323	0.371
Mixing and placing concrete†	1,408	1.614
Finishing concrete work	56	0.064
Erection of mixer	61	0.070
Totals	$2,629	$3.014
Supplies.		
Coal	$ 24	$0.027
Oil for forms	31	0.035
Totals	$ 55	$0.062
Grand totals for concrete work	$9,014	$10.335

The work was carried on under considerable difficulty. The excavation was interrupted by frequent rains, and the banks slipped, causing the handling of considerable additional material. The work of driving piles was also frequently interrupted by rain, and as a consequence the extra work of placing concrete did not start until late in the fall, and had to be prosecuted by two shifts, working day and night, Sunday included, until it was finished. The conditions are reflected in the high unit cost of excavation. The cost of placing reinforcing bars is about typical, while the cost of placing concrete at $1.61 per yard is abnormal, owing to the fact that in this item is charged considerable general labor, which could not be otherwise apportioned.

The specifications originally contemplated the use of crushed limestone, but there was submitted to the engineer samples of very good gravel at a price of $1 per cu. yd. This gravel was clean, and contained enough sand to fill the voids without additional material; in fact, some of it contained slightly too much sand. The cost of sifting out the coarse material and again sifting out the fine material, and then mixing the two together in the proper proportions was found to be 32 cts. per cu. yd. This was used for all arch concrete, but for abutments the mix of the gravel as delivered was deemed satisfactory, as it did not vary greatly from the proper proportions. The footings were made of crusher rock dust and limestone, which had been owned by the city for several years. This material is considered as costing the same as gravel.

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*Condensed and rearranged, with additional data, from the "Canadian Engineer," Jan. 15, 1909.

**Pile driving was subcontracted.

†This item also includes bracing and general labor.

The eleven Lidgerwood unloaders in the Central Division of the Isthmian Canal during the month of December unloaded a total of 2,821 trains composed of a total of 49,113 cars. Of this number, 1,367 trains composed of 23,249 cars were unloaded by the five unloaders at Tabernilla; 725 trains, composed of 12,750 cars, were unloaded by the three unloaders at the Miraflores dumps, and 729 trains, composed of 13,114 cars, were unloaded by three unloaders at La Boca. As all the cars were of 20-yd. capacity the material unloaded represented about 982,260 cu. yds., states the Canal Record. In addition, there were 2,638 Western dump cars, containing about 44,000 cu. yds. of material, unloaded at the La Boca dumps during the month.

During the field season of 1908 the topographers of the United States Geological Survey mapped 26,994 square miles—6,024 square miles in the Atlantic division, 6,069 square miles in the Central division, 3,875 square miles in the Rocky Mountain division, and 11,026 square miles in the Pacific division. The surveys included work in 32 States and Territories, much of it in cooperation with States, which pay one-half its cost, the National Survey paying the other half.

Earth and Rock Section

Note: This Section is devoted to methods and costs of excavating earth and rock and building embankments. It will cover the grading of roads and railroads, diking and canal work, dredging, building reservoirs and earth dams, sewer and water pipe trenching, quarrying, etc.

Comments on the Use of Wagons in Transporting Earth.

For short hauls wheelbarrows, scrapers and carts are used for transporting earth, but when the distance becomes such as to make their use too expensive, small cars or wagons are employed. The use of cars will be considered at some other time, for the present we will confine our comments to the use of wagons for earth excavation.

A decade ago wagons were used comparatively little, but since then vast improvements have been made in wagons and also in the machinery for loading them. Earth at one time was nearly always loaded by hand with shovels, but today wagons are loaded with elevating graders, with trench excavating machines, with steam shovels and with special loading devices. In order to guide the material into the wagon bed, there have been devised various kinds of chutes and hoppers, into which the earth is first loaded. Then wagons are often loaded by means of scrapers through traps and by dump buckets or skips operated by derricks or cable ways.

Our first consideration will be the different styles of wagons and then comment will be made upon the method of loading them. The first style of wagon used for earth transportation was the kind now found in common use in most sections of the country on farms. This wagon consists of the ordinary running gear with front and back wheels connected by a coupling pole, and with wheels having, as a rule, 2-in. tires. The body is a rectangular box, made of 1-in. planed boards, bound on top with strap iron. Such a wagon, not being made specifically for earth work, is quickly knocked to pieces, especially the body or wagon bed. The narrow tread of the wheels on soft roads quickly cuts up the roads into ruts and makes the work very hard for the horses. These were all objections to the use of this style of wagon, but one greater than any of these was the fact that all the material had to be shoveled out of the wagon. At the end of the body near the tail gate, two men could rapidly push out in the square pointed shovels about one-quarter of the load, but the rest of the earth had to be shoveled over the sides in exactly the same manner as earth is shoveled into wagons. To overcome this difficulty it became the custom to cut holes in the bottom of the wagon about a foot wide and 2 ft. long, one in the fore part of the body and one near the middle. A small board was put over these holes, when the wagon was loaded, and then by lifting up these boards by means of a pick, a great mass of the earth fell through the holes, while the rest of the load was quickly pushed by shovels through them or out of the tail gate. This reduced the time necessary to unload such a wagon by one half, but even with this improvement the cost of dumping or unloading remained excessive.

This idea of dumping through the bottom brought into use "the slat bottom wagon." This consisted of the same style of running gear, but the body bought with the wagon was taken off the bolster, or the wagon was bought without a body or bed. On the bolster of the wagon, 2 x 4-in. scantlings were placed to make the bottom of the wagon body, these pieces being known as "the slats," and two 12 or 14-in. boards were used as the sides of the body. The slats and the side boards were all drawn down with a draw knife on each end to a handle, of a size easy to grip by a man. In cities, in order to prevent the earth from spilling from either the front end or the rear of the wagon, cleats were nailed on each side board near the two ends, so as to hold in place two end boards cut to the proper length. These end boards had hand holes cut in them so that they could be readily pulled out, when it was desired to do so.

When the slats were all in place and the side boards placed against the standards on the bolsters, the wagon was ready to be loaded. To unload the wagon at the dump, the driver stands on hounds of the wagon, where the tongue fits into them, while the dump man stands on the ground at the rear of the wagon. Each grabs hold of the handles on one of the side boards and lifts it up, thus spilling some of the earth from the wagon. The other side board is then raised. These boards are placed on top of the earth still remaining in the wagon. Then each slat is raised in the same manner and in from two to three minutes the load is thus dumped. All the earth falls clear of the wagon, except a small amount that falls onto the coupling poles and running gear, which is shaken off by the motion of the wagon as it starts to leave the dump. When end boards are used in the wagon they are first pulled out by the driver of the team, before the sides are raised. These boards should never be used on work in the country, especially on comparatively short hauls, as they retard the work of dumping the load, and the time thus wasted may mean that another wagon will have to be put in the run. On long hauls, especially in cities, a larger load may be carried with the aid of the end boards, and the earth is kept from spilling onto the streets. When these end boards are not used the side boards should be made at least 14 ins. deep so that they can be placed down on the bolsters alongside of the slats, which will hold the sides in place as the wagon is being loaded, and will give a wagon body 12 ins. deep. This allows a greater load to be carried as if the side boards rest on top of the slats, which are used with the 4-in. way resting on the bolsters, the side boards must be placed at a slight angle with the standards to prevent them from falling and thus interfere with the loading of the wagon.

The side boards should be reinforced on the outside with four cleats or pieces of battens, about 2 ins. wide. Two of these should be nailed near each end, one on each side of where the side board rests against the standards. These battens not only reinforce the sides and prevent them from being split or broken, but also show the driver the exact position in which to place the side boards and the slats, both side boards and slats being of the same length, so as to bring the load directly over the wheels, and prevent the body interfering with the free action of the horses, or having the wagon bed stick out too far beyond the rear wheels. This is an important matter.

It was soon found that the ordinary running gear of a farm wagon was built too light for use with slat bottom body, and the narrow tread wheels cut up the roads and runways too quickly, so wagon manufacturers made a heavier running gear with wheels of 3 and 4-in. tread for contractors' use for earth excavation and other hauling for construction work. Brakes are seldom used on such wagons as there is no regular body on which the rod and handle can be run to the front of the wagon to the driver's position, and it is not possible for him to drive his team to advantage from the rear of the wagon, where he can attend to the brake. The brake handle also interferes with the loading of the wagon, especially if the handle sticks up.

A slat bottom wagon bed is generally made of such dimensions as to allow of the body holding 1 cu. yd. struck measure. To do this the coupling pole that is ordinarily put in the wagon by most manufacturers has to be lengthened. Such a slat wagon body when loaded heaping full will generally carry 1 cu. yd. place measurement, especially if end boards are used.

When the wagon is dumped the driver should leave the dump before placing the sides or slats in position, as the jarring from the motion of the moving wagon when it is empty will generally displace them. The slats and sides should be put in place just before the wagon enters the cut or pit to be loaded.

For general use for hauling earth, the patented dump wagons are rapidly taking the place of the slat bottom wagon. The principal reason for this lies in the fact that the load is almost instantly dumped, while it takes from two to three minutes to dump a slat bottom wagon. Then, too, the patented dump wagon is made of larger carrying capacity, and the running gear being built especially for hauling earth and rock is stronger, and for work in the country the tires of the wheels are broad.

However, the slat bottom wagon will always be used under some circumstances. For instance, a contractor may have only a single cut in which he may have to use wagons for hauling the excavated materials. The yardage may not be large enough to warrant the purchase of a lot of dump wagons, hence already having on hand other wagons for hauling lumber, coal, pipe and other supplies, the thing that will suggest itself will be to put slat bottom beds on the running gears already owned and use them. It is very true that to-day patented dump wagon bodies could be purchased and placed on the running gears, but with no other work for them in the future, it is doubtful if even the purchase of the bodies will be justified. This is especially so if the haul on the material is long, as then the time wasted with slat bottom wagon on the dump is small compared to the time consumed in making the round trip with the wagon, and may be justified, as horses after a long hard pull need a few minutes, as a "breathing spell." If the haul is short, then the conditions may make the purchase of the dump bodies economical. Many contractors are learning that to have a half dozen of these bodies among their outfit or plant is a good investment. But, as stated before, some slat bottom wagons will always be used.

Nearly all dump wagons are covered by patents. There are a large number of these patented dump wagons on the market, each varying in some detail or other from the others, yet they can be divided into three classes or styles: (1) Bottom Dump; (2) End Dump; (3) Special Dump.

The first class is the largest, and is familiar to most men engaged in construction. The bottom of the wagon is divided into two doors, in the most cases hinged to the sides of the wagon, and joining in the center of the body. These doors are made of either steel or wood, and are held in position by means of chains that wind around a bar or spools. A lever and a ratchet winds up the doors to their proper position for carrying a load. This can be done by the driver while the wagon is in motion. To dump the load, a lever is thrown to release a fall in the ratchet, the weight of the load thus forcing open the doors, and dumping itself from the wagon body. It is not necessary to stop the wagon in dumping, unless it is desired to dump all the load in some particular spot.

Bottom dump wagons are made in from 1 to 5 cu. yds. capacity and are built both of wood and steel. The front wheels of these wagons in turning go under the body, with the result that a team can turn in its own length. This is an important consideration in building narrow and high embankments, as it is then possible for the team to travel out on the embankment and return to the loading pit over the same runway. The driver sits on the front of the wagon, a seat being provided for him convenient to the levers he has to operate. As the body is permanent, brakes can be provided and so arranged that they will not interfere with either the loading or dumping.

Improvements in dump wagons have been rapid, and any one needing wagons has a large number of good designs from which to select. The essential features to keep in mind in buying wagons of this character are several. The materials from which it is built should be good. The wagon should be of easy draft; one that pulls hard unnecessarily tires the horses. The inside of the body or box should be free of chains, bars or spools. The rear and front chains on the doors should wind up at the same speed. The doors should lap in some manner, so as to be tight when closed, to prevent leaking. The doors should hang free when released, and the hinge should be such as to allow the door to slide away from the load, or else the doors will bind against the material dumped if the latter is hard, as indurated clay, gravel or stone, thus stalling the team and wasting time. The dumping device should be of simple design so as to release the load instantly the driver grabs the lever. A slow dumping device adds to the cost of spreading earth on the dump, as the loads will not be deposited in the places designated by the dumps man.

End dump wagons, like the bottom dump wagons, are nearly all patented. They can be divided into two divisions, namely those with tail gates and those without tail gates. Those without tail gates generally have the bodies built of steel, and the body is built of such a shape that the load is discharged by gravity when the wagon bed is tilted for dumping. One advantage that this style of wagon possesses is that none of the load can spill or leak out unless too much of a load is placed on the wagon. This style of wagon is not often used for earth excavation as the wagon is quite heavy, and owing to the shape that is given it, so it will dump, its carrying capacity is reduced.

Those with tail gates are used for earth transporation, and several styles of this class of wagon are in common use in New York city. For dumping into hoppers or bins, and through chutes, or onto scows and barges or into railroad cars they are better adapted than bottom dump wagons as the horses can be backed up to the dumping place. For the above listed classes of work and for dumping on piers and wharves this style of wagon is well adapted. This class of wagon can also be used in building embankments and waste banks by back dumping. Some end dumping wagons are no higher than bottom dump wagons, but those of large capacity must sit higher from the ground so as to give room for tipping in dumping. This makes them difficult to load by men with shovels.

There are now in use in different sections of the country a number of types of special dump wagons. Many of these we expect to describe later. They are either designed for special work or to suit special dumping arrangements. Some dump through the bottom, some turn over in dumping, and others must be used with special dumping apparatus or must be dumped by means of a derrick or cableway.

Dump boxes or bodies meant to be used on any running gear are either bottom dumping or end dumping. The bottom dump ones have four doors instead of two, as the doors cannot be very wide owing to the coupling pole of the running gear interfering with their movements. The regular bottom dump wagon does not have a coupling pole. . The dump boxes are quickly growing in favor with contractors for earth moving.

(To be continued.)

Loading Blast Holes and Driving Small Drifts.*

BY GEORGE C. M'FARLANE.†

As everyone knows, dynamite is detonated from a solid into a gas by pressure. When the detonating cap lets go it compresses about 2 cu. in. of the surrounding mass of dynamite sufficiently to cause dissociation; the transition from solid to gas must occupy a definite interval of time, about one-twenty thousandth of a second. The initial explosion of one or two cubic inches of dynamite in the immediate vicinity of the cap would generate sufficient force to compress the entire charge to the dissociating pressure.

Detonation of a mass of black powder is effected by a uniformly expanding zone of flame starting from a spark. With dynamite detonation is accomplished with a succession of jolts separated by imperceptible but definite intervals of time. This explains why a strong cap and a well packed charge give definitely better results. The strong cap detonates enough of the surrounding charge to make a strong primary explosion. When the charge is well tamped the primary explosion would compress two or three feet of powder to the pressure of dissociation. With a weak cap and poorly compacted dynamite, it is conceivable that it might take three or four jolts to explode the whole charge.

The reason the ground around the primer is badly shattered is that the primary explosion of an ounce or so of dynamite hasn't power enough to spring the rock burdened on the hole, and as the tamping is tightly up against the explosive, the pressure crushes and shatters. In the interval that precedes the detonation of the main portion of the charge the gas from the primary explosion blows the tamping back an inch or so and cushions the main explosion to a certain extent. For these reasons I believe a cap should be in the top of a charge, because it is evident that the main or secondary explosion tears the rock out. With a cap on top a small part of the upper end of the charge is rendered useless for rock breaking purposes; with the cap in the bottom a small part of the bottom of the charge is consumed in shattering the bottom of the hole. With a lifter or back hole it wouldn't make a particle of difference, as far as breaking ground went, where the cap was; with a cut hole, where the power is needed on the toe of the hole, a cap on top of the charge will tend to put the locus of the principal concussion a fraction of an inch nearer the bottom of the hole.

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TAMPING.

In breaking rocks with mud-caps, I find it makes a very material difference whether or not the detonating cap is placed on top of the dynamite. The most effective way to break a rock is to pick out a little depression and form a wall around it with plastic clay; fill this crater with dynamite, lay the cap on the center and cover the whole with soft clay. If the cap is shoved down into the dynamite the breaking power of the mud cap is lessened. The only possible explanation of this phenomenon is that when the detonator is near the bottom of the dynamite, the detonation lifts a portion of the explosive bodily from the rock before it bursts into gas. High explosives must have a good contact with rock which it is desired to break. When a mud cap is placed on top of a stone, the explosive is usually plastered down tight against it, and the stone is broken into several fragments; if the same quantity of explosive were poked under the stone it would have poor contact and do very little execution. This is the reason why dynamite is supposed to strike down.

In regard to tamping a hole, I think that ordinarily 8 or 10 ins. of clay tamping is enough. Strong cut holes require more tamping to get the full power of the explosive. Take the case of a 6-ft. incut hole in the face of a drift, the hole being $1\frac{3}{4}$ in. in diameter and loaded with 32 ins. of 60-per cent explosive. The center of the charge would be burdened 4 ft. and in hard granite or trap it would take one two-thousandth of a second for the concussion to travel from the explosion to the free face. This means that for a period of one two-thousandth of a second the gases of the explosion must be confined. At the end of the period, the momentum imparted to the rock tears it away from the solid. During this period the tamping will be subjected to a pressure of 150,000 lbs., sufficient to force 18 ins. of clay or 3 ft. of water tamping 6 ins. This shows that 18 ins. of clay tamping is none too much. A 6-ft. hole burdened 30 ins. would kick 8 ins. of clay tamping back 6 ins. before the rock cleaved from the solid.

A quick way to tamp up a round of holes is to have one of the muckers make a candle box full of clay slugs $1\frac{1}{2}$ ins. in diameter and 4 or 5 ins. long. In loading twist a piece of paper around one end of the slug and they are easily shoved in and rammed home with the loading stick. I think the best results are obtained by putting in 18 ins. of tamping for the incut holes and 11 ins. for the other holes. Using a 2-ins. time interval on the fuses, the fire in the fuse will be several inches in the tamping before an adjacent hole goes off. It is no uncommon thing for a hole to kick off 2 or 3 ft. of another hole; as long as the fuse was burned down into the tamping and firmly bedded in a foot or so of clay, the spent fuse would break in case a collar blew off; otherwise the fuse might be pulled out of the hole. I noted a case in which one hole cut another hole off in the middle of the powder charge; the hole had pulled back to a slip and the dynamite was cut so smoothly that there was no sign of a hole on the slip until one of the men stuck his pick into it.

This cutting off of holes is a prolific source of accident. If the holes are overloaded as they often are, powder is thrown in the muck. Of course, there is no method of blasting that will eliminate accidents altogether, because things are liable to happen in blasting a round of holes that no man can foresee.

DRIFTING AND CROSSCUTTING.

In driving drifts and crosscuts where there are no good slips or floors to break to, the "V" or pyramid incut will be found to be the most satisfactory. In narrow drifts four holes will be enough and they should be drilled so that the points nearly or quite intersect. In drifting, I think the double-screw column is much handier than a cross bar, although it takes longer to rig up on a column than it does on a bar. In uneven ground, the machine often runs up or down on a hole; with a column and arm it is possible quickly to adjust the machine for alignment and often prevent the steel from fitchering and running tight. In very tight, hard ground, it pays to set the column as close to the face as the machine will work; drill the holes about $5\frac{1}{2}$ ft., and give them as much lift as possible. Of course, when the cut holes are drilled with the machine close in, the column has to be rigged back about 18 ins. to drill the back holes and lifters.

If the ground is only moderately hard it pays to drill the cut holes so as to bottom $1\frac{3}{4}$ ins.; then four pounds of 60 or 75 per cent dynamite can be put in the bottom 30 in. of each hole. If the ground is extremely hard, time can be made by drilling the holes smaller, bottoming them $1\frac{1}{4}$ or $1\frac{3}{8}$ ins. Not only do small holes cut faster and hold their gage better, but it is also far easier to collar a hole on a pitching face with a small starter.

When small holes are used it will be necessary to spring the four cut holes with about four $1\frac{1}{4}$-in. sticks of 60 per cent, then blow them out well with a blowpipe; this will chamber the holes so that they will take enough powder to throw out the incut. It takes about 40 minutes to spring four holes (15 minutes to tamp up, 15 minutes to get the smoke out of the drift, and 10 minutes with the blowpipe to clean and cool the holes.)

ORDER OF FIRES AND MISFIRES.

In most cases it is a decided advantage to blast the incut with a battery, although it takes more time than if the holes are all loaded and fired in one round. When fired with a battery the cut generally kicks the collars off a few of the surrounding holes, so that after the incut round there isn't the same danger of holes cutting one another off and causing misfires and scattering powder in the muck. Again if the cut does not come out well the bottoms can be reloaded and spit with the squaring holes. When the incut is blasted separately, there isn't much danger of the inexperienced men lighting holes out of their proper order and perhaps spoiling the whole round.

If a hole that is solidly tamped with about a foot or so of clay tamping misses fire, it is certainly no joke to dig the tamping out. If the caps are always snapped, and waterproof fuse is used, such mishaps are bound to be extremely rare. One method of drawing tamping that is a little safer than picking it out with a scraper is to burn it out by repeatedly loading up whatever collar there is to the hole; after two or three shots the concussion will go through the tamping and set off the main charge. Another method, which I think is safer, is to make a little tank by capping both ends of a 6- or 8-in. pipe about 3 ft. long, tapping in a couple of nipples on opposite sides of the pipe. This tank would hold two or three pails of water. To blow tamping use a small tip on the blowpipe; wedge a plank or board across the drift and after inserting the blowpipe in the hole, lash it fast to the board so that it cannot kick back. Now run the blowpipe hose to the water tank and run the connecting hose from the air pipe to the upper nipple of the tank. Use a valve two or three hundred feet back from the face for turning on the air pressure. This method works well in an upper or flat hole; it will often wash out a foot of tamping without shifting the blowpipe.

At the close of the calendar year 1908 there had been purchased for Panama Canal work 183,730 bbls. of cement. In addition to this amount, 20,000 bbls. had been ordered.

Roads and Streets Section

Note: This Section is devoted to methods and costs of road and street construction. It will cover road building in all its details, the construction of pavements, sidewalks and gutters, the testing and use of paving materials and the machinery and tools used in road building and paving.

Cost of Street Paving in Fifty American Cities.

The accompanying tables show the construction and cost of street paving in about 50 representative American cities. These figures were collected by the committee on Roads and Pavements of the Illinois Society of Engineers and Surveyors and were reported at the annual convention held last week. The records cover macadam, asphalt and brick and block pavements and give the materials used, thickness and cost. The costs given are, of course, costs to the cities and not costs to the contractors. No very accurate general conclusions can be drawn from these records, and in fact this was not the purpose of their collection; they show individual records of city paving work and for this are deserving of careful study. Mr. A. N. Johnson, State Engineer, Illinois, was chairman of the committee, making the report from which the tables are taken.

COST DATA ON PAVEMENTS:—BRICKS.

Report From.	Nature of Foundation.	Thickness of Foundation, Inches.	Cushion Thickenss and Character.	Make of Brick or Kind of Block.	Nature of Filler.	Approx. No. Sq. Yds.	Cost per sq. yd Excluding Curb.
Ala., Birmingham	Concrete	5	2" sand	Graves shale brick	Sand	47,500	$1.90
Ariz., Phoenix	"	4	1" "	Purington	Pitch	10,000	3.22
Conn., Bridgeport	"	6	1½" "	Mack block	Cement	5,567	2.79
" "	"	6	1½" "	U S.Wood Co.w'd blk	Asphalt	874	3.40
" Hartford	"	5	1-2" "	Granite block	Cement	1,000	4.00
Ga., Macon	"	6	1½" "	Reynold's block	Pitch	106,456	2.08
Ill., Cairo	"	5	2" "	Peebles block	Asphalt	50,000	[1]1.99
" Champaign	"	6	1¼" "	Culver block	Sand	2,388	1.48
" " "	"	6	2" "	" "	Grout	7,000	1.62
" " "	"	6	2" "	" "	Asphalt	2,400	1.73
" " "	"	6	1½" "	Wood block	"	400	2.60
" Decatur	"	4	2" "	Black Danville brick	Cement& asphalt	4,700	1.65
" "	"	6	2" "	" " "	"	24,275	1.85
" "	"	6	2" "	Terre Haute brick	Asphalt	2,187	2.00
" "	"	4	2" "	Brazil block	Cement	6,773	1.65
" East St. Louis	"	6	"	Albion	"	10,900	1.40
" "	"	6	"	Banner	Asphalt	10,800	1.55
" "	"	6	"	"	Cement	3,500	1.58
" "	"	6	"	"	"	2,850	1.50
" "	"	6	"	"	"	8,100	1.65
" "	"	6	"	"	"	2,500	1.53
" "	"	6	"	"	"	2,950	1.64
" "	"	6	"	Granite block	Sand	12,000	2.27
" Galesburg	"	4	"	Purington block	Cement	4.224	1.67
" Harvey	"	8	1" "	" "	Sand	24,000	1.95
" Joliet	"	6	6" "	Barr Brick	"	6,000	1.65
" "	"	6	"	"	"	700	1.94
" La Salle	"	6	2" "	"	"	8,000	1.60
" Moline	"	5	1½" "	Purington block	Cement sand plastic		1.79 to 1.90
" Taylorville	"	6	2" "	Springfield brick	Asphalt	9,250	1.56
" Winnetka	"	8	"	Purington block	Sand	6,000	1.70
Ind., Ft. Wayne	"	6	"	Metropolitan	Cement	15,132	1.65
" "	Broken stone	6	"	"	Sand	2,717	1.30
" Indianapolis	Concrete	6	"	Ind. block	Cement	128,500	2.00
" "	"	6	1" "	Hard pine	"	10,049	2.40
" Kokomo	Old macadam	8	2" "	Culver block	"	8,000	1.30
" Muncie	Concrete	6	1½" "	Metropolitan	"	25,000	1.84
" "	"	6	"	Wassel	"	21,000	1.62
" "	"	6	"	Logan	"	20,000	1.58
" "	"	6	"	Brazil block	"	67,000	[2]1.56
" "	"	6	"	Metropolitan	"	20,000	1.59
" So. Bend	"	6	1" "	Barr block	"	3,010	[3]1.34
" "	"	6	"	Clinton block	"	400	1.37
" "	"	6	"	Indiana block	Sarco cement	5,039	[4]1.32
" "	"	6	"	Trimble block	Pioneer	3,852	[5]1.40
Ky., Covington	"	6½	1½" "	Athens	Cement	12,530	1.85
" "	"	6½	"	Spillman	"	16,000	1.82
" "	"	6½	"	Portsmouth granite	"	4,000	1.73
" "	"	6½	"	" "	"	2,000	1.65
" "	"	6½	"	Carlyle	"	2,900	1.84
Mass., Lawrence	Gravel	6	2" to 3" sand	Granite	"	20,000	2.15
" New Bedfo'd	Concrete	5	2" sand	"	Sand	17,300	3.15
" Springfield	"	4½	Dry cem't mort	Creo-Resinate	Cement	......	3.27
Ill., Chicago	"	6	2" sand	Creosoted wood	Sand	32,270	3.44
" "	"	6	"	" "	Tar	17,900	3.49
" "	Slag	6	"	Purington and Met'l'n	Tar	28,050	2.05
" "	Slag	10	"	Metropolitan	Tar	1,410	2.25

[1] $1.99 to $2.04. [2] $1.56 to $1.61. [3] $1.34 to $1.47. [4] $1.32 to $1.44. [5] $1.40 to $1.43.

Expenditures for New York State Barge Canal Work for the fiscal year ending Sept. 30, 1908, include the following: For preliminary engineering, $536,859.85; for construction engineering, $205,930.34; for advertising for bids on contracts, $2,623.90; for recording appropriations of land, $193.

Court Decision Regarding Bitulithic Pavement Patents.

A decision of interest to paving contractors, engineers and municipal authorities was rendered Jan. 5, 1909, by the U. S. Circuit Court of Appeals of the Sixth Circuit in the case of Warren Bros. Co., vs. the city of Owosso, Mich. The suit was brought against the city of Owosso on account of an alleged infringement of patent No. 727,505, issued May 5, 1903, to Frederick J. Warren for "a new and useful improvement in street pavements," since known as bitulithic pavement. The Barber Asphalt Paving Co., which constructed the alleged infringing pavement for the city, defended the suit. The U. S. Circuit Court reversed the decision of the lower court and ordered an accounting to ascertain the damages to be assessed by the infringement.

Circuit Court Justice Lurton's statement of the case was as follows:

"The invention relates to an improvement in that class of street pavements consisting of a foundation of mineral matter and a top surfacing, or wearing surface, made of graded mineral matter intimately associated and united by means of asphalt or coal tar. The inventor claims as his discovery that the best conditions of this top or surface of a mineral roadbed is that this top or wearing surface of such pavements 'must be made as dense, as free from voids, as possible, and also stable and non-liable to displacement."

"Under the art, as practiced theretofore, the inventor says that the mineral matter united by plastic material has generally been fine gravel or sand or broken stone, not exceeding pieces of stone or other ground material above one-tenth of an inch in diameter. That the smallest percentage of voids under that method was 21 per cent of the aggregate.

"He declares that to secure stability there must be a departure from this method, and that by the employment of larger sized pieces, 'say up to those which will pass through a two-inch ring and employing with these larger grains proper quantities of the smaller sizes down to an impalpable powder, it is possible to reduce the voids of the mineral base below 10 per cent of its bulk.'

"Such an assemblage, he says, compacted together, will form a dense, solid, homogeneous, compact body with the smallest percentage of voids and possessing the highest degree of stability and one in which the largest and smallest pieces are associated with each other indiscriminately throughout the structure and one which, because of the sizes of the pieces and their arrangement with respect to each other, offers the smallest areas of surface for the attachment of the plastic composition to them, so that not only is a superior binding effected, or union obtained by the plastic composition, but a smaller quantity of it is necessary for the purpose of obtaining the superior result or product.'

"The specifications lay stress upon the fact that the stone components of different sizes are not to be used in layers of corresponding sizes, but mixed together, the large, the small, and the dust in one aggregate, with the asphalt or other plastic composition permeating the whole mass and uniting the particles by filling in the voids and making a solid surface. This composition is spread uniformly over the top of a roadbed foundation, preferably of macadam, and is intended to form only the top or wearing surface of such a roadbed. This top section, he adds, may, if desired, be smeared over 'with a surfacing of clear asphalt or other bituminous composition of any desired nature.'

"The mixture preferred by the inventor is described by the inventor in his specifications as follows:

"'I prefer to use from one to three per cent of impalpable powder, from ten to thirty per cent of material between impalpable powder and one-fourth of an inch in size, and from fifty to eighty per cent of material larger than one-fourth of an inch in size. I have found that these ingredients when associated together produce a mass or body having less than twenty per cent of voids. I prefer to use as the uniting or plastic composition one which comprises asphalt and an oil flux heated to a moderate heat to provide the requisite fluidity; but I do not confine myself to any special form of artificial or natural asphalt.'

"This mineral part of the composition, the patentee says, is to be 'intimately associated with the plastic asphalt composition, which is then spread uniformly upon the prepared foundation and which in setting becomes very dense, solid and freer from voids than any pavement of which I have knowledge.' Among the advantages claimed in the patent specifications are: First, that the percentage of mineral matter employed is increased and that of the bitumen decreased, thereby cheapening the cost; second, that the wearing qualities of the pavement are much increased, due to the fact that 'a very rigid and stable effect is obtained which reduces strain and wear upon the uniting medium, more of the wear being borne by the mineral base and less by the uniting medium'; third, the reduction of voids formed by the mineral constituents, in that they are larger and fewer, the plastic fluid filling such spaces with a cellular structure, which, it is claimed, adheres better to the surface of the stone pieces than when the interstices of the composition are smaller and more numerous.

"The claims in issue are the 5th, 6th, 9th and 11th, and are as follows:

COST DATA ON PAVEMENTS—ASPHALT

Report From	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2	[illegible]	$1 [illegible]
Ark. [illegible]	[illegible]	4	1"	[illegible]	[illegible]	[illegible] 500	[illegible]
Conn. [illegible]		6	1½	[illegible]	1½	[illegible]	[illegible]
						17 [illegible]	1 [illegible]
" "			1½	"	1½	[illegible]	[illegible]
" "		6	2	"	1½	[illegible]	[illegible]
" "		6	1½	"	1½	[illegible]	[illegible]
Ill. [illegible]		[illegible]	[illegible]				
			1½" [illegible]	[illegible]	2	[illegible]	[illegible]
" J[illegible]		6	2"	[illegible]	1½	7 [illegible]	[illegible]
Ind. A[illegible]		5	[illegible] 1" [illegible] [illegible] 1" [illegible]				
			[illegible]	[illegible]	2½	[illegible] 500	1 [illegible]
" Ft. Wayne	"	6	1" [illegible] 1" [illegible]	[illegible]	2½	21 [illegible]	1 75
" Indianapolis	"	6	1"	[illegible]	2	107 [illegible]	[illegible]
" Kokomo		6	1½"		2	11 [illegible]	1 [illegible]
" South Bend		5	1"	"	2	[illegible]	1 [illegible]
Mich. D[illegible]		6	1½" [illegible]	"	2	400	[illegible]
N. J. Camden	"	4	S[illegible] 1"	"	1½		1 [illegible]
" "		6	S[illegible] 1"	[illegible]	2		1 [illegible]
" E[illegible]	"	6	1½"	T[illegible]	2	1 [illegible]	[illegible]
" "	"	6	1½"	"	2	7 [illegible]0	[illegible] 49
N. Y., Buffalo	[illegible]	6	1½"	"	2	20 [illegible]	[illegible]
" "	[illegible]	6	1½"	"	2	[illegible]	[illegible] 12
" Troy	A[illegible] concrete	6	1½" [illegible]	"	2	[illegible]5	2 7[illegible]
Ohio Columbus	"	6	1"	"	2		2 10
" Dayton	"	6	1" [illegible] [illegible]	T[illegible]	[illegible]		1 [illegible]
" Toledo	"	6	1" [illegible] 1" [illegible]	T[illegible] A[illegible] [illegible]	2	10 000	[illegible] 1 [illegible] [illegible] 1 [illegible]
" Youngstown	"	4	1" [illegible] Asphalt [illegible]	Tr[illegible]	2	[illegible] 040	1 4[illegible]
" "	"	6	"	"	[illegible]	10 4[illegible]	[illegible]
Pa. Chester	"	6	1½" "	"	2	7 0[illegible]0	[illegible]
" Erie	"	5	1" [illegible]	[illegible]	2	[illegible]51 [illegible]	1 27-1 [illegible]
" "	"	5	"	"	2	[illegible]0 7[illegible]	1 35-1 75
" "	"	5	"	C[illegible]	2	5 [illegible]45	1 [illegible]5
" Harrisburg	"	6	1"	[illegible]	2	125 000	1 [illegible]
" Scranton	"	6	1" gra[illegible] [illegible]	T[illegible]al	2	[illegible]0 1[illegible]1	2 1[illegible]-2 [illegible]0
" Wilkesbarre	"	6	1"	"	2	[illegible] 000	1 1[illegible]-1 [illegible]0
R. I., Providence	"	6	1½" [illegible]	Ber[illegible]	1½	[illegible]	[illegible] 25
D. C. Washington		6	2" compressed to 1½"	B[illegible] [illegible]	1½	100 000	1 [illegible]
Ill. Chicago	Concrete	6	1½" asphalt cement & [illegible]	Ca[illegible] Var[illegible]	2	[illegible]1 000	2 0[illegible]

COST DATA ON PAVEMENTS—MACADAM

Report from	1st Course			2nd Course			Material for Binder Course	R[illegible] Thickness Consolidated [illegible]	[illegible]
	Thickness Loose In.	Size of Material In.	Kind of Material	Thickness Loose In.	Size of Material In.	Kind of Material			
Ala., Birmingham	4	½-2½	Slag	4	[illegible]	Chert	None	[illegible]	$ 40 [illegible]0
Conn., Bridgeport	*4	½-2	Trap rock	*2	1-1½	Trap rock	Screenings	6	[illegible]5
" Hartford	12	6-12	Trap rock	6-8	2	Trap rock	½" & [illegible]	12	51
Ill., Harvey	6	2½-4	Limestone	6	1½-2½	Limestone	Screenings	12	9[illegible]
" Rockford	6	4-6	"	5	1-2½	"	"	8	40
Ind. Muncie	6	1-4	"	6	½-1	"	"	10	55
" Richmond	6	2½-4	"	*4	2½	"	"	12	[illegible]0
Mass., Lowell	5	2½	Trap rock Slate "	3	1½	Trap rock Slate "	Trap rock, Slate "	[illegible]	[illegible]0
" New Bedford	12	1½-3	Granite				Screenings	12	[illegible]0
" Newton	5	2½	Trap rock	2	1½	Trap rock	Dust and screenings	[illegible]	70
" Springfield	4-7	2	"	1½	1½	"	"		50-75
Minn. Duluth	6-8	1	"	1½	1	"	"	7	70
N. J., Camden	5	2½	"	5	1-1½	"	"	8	[illegible]5-[illegible]
" "	7	1½-2	"	3	½-1½	"	"	7	1 01
Ohio, Cleveland	9	1-2½	L[illegible]	3½	1-2	Trap rock	"	12½	2 [illegible]
" Columbus	8	½-[illegible]	"	6	½-2	Limestone	Screenings	12	[illegible]-[illegible]0
" "	5	½-[illegible]	"	4-6	½-1	"	"	6-8	56
" "	8	0-6	Sa[illegible]	6	½-2½	"	"	6-8	80
" Dayton	6	1-4	Limestone	3	2	"	"		1 00
" Springfield	5½	[illegible]-2½	"	5½	1½-2½	"	"	10	45
" "	4	[illegible]-2½	"	3	1½-2½	"	"	6	[illegible]
" Toledo	5-8	2½-4	"	4-6	1-2½	"	"	7-12	[illegible]
Wis. La[illegible]	8	1-[illegible]	"	[illegible]	2-5	"	1½" [illegible]	12	[illegible]0
" Madison	2x4 12x16	6-8	"	4	1-4	"	Screenings	12	70-86
" "	6		"	6		"	"	4	[illegible]
" Sturgeon Bay	7	3-4½		5	1½-2	"	"	4	[illegible]
D. C. Washington	6	2	Trap rock	[illegible]	1-[illegible]	Trap rock	"	6	[illegible]0-75
Ill. Chicago	11	6	Slag	*3	1-2½	Limestone	Cement & screenings		1 [illegible]0
" "	*8	6	Slag	*4	1-2½	"	"		[illegible]
" "	*6	4	Limestone	*3	1-2½	"	"		1 [illegible]

* Rolled

"'5. In a street pavement, a bituminous mineral structure the mineral ingredients of which are fixed and of several grades, so graded as to give the structure an inherent stability.

"'6. A bituminous street pavement structure containing mixed mineral ingredients of such grades as to give the structure an inherent stability.

* * * * * *

"'9. A street pavement wearing section

composed of a mineral structure of inherent stability formed of several grades of material so proportioned as to have a per cent of voids less than twenty-one per cent of the whole, in combination with a comparatively soft bituminous binder filling said voids and rendering the whole permanent in nature and elastic and waterproof in character.

"'11. A street paving structure composed of a mixture of mineral or wearing ingredients and a plastic binder, the space between the mineral ingredients being less than twenty-one per cent of the whole, and the plastic binder occupying said space.'"

In its decision the court stated that the street pavement of the Warren patent is plainly differentiated from the pavement structures in practical use before his invention. It was further stated that the record of proceedings, briefs, and oral arguments reduced the case to the question of whether the invention of the patent had not been anticipated. The court considered a number of alleged anticipations of the patent made by the defendant company, chief of these being the construction of a piece of sidewalk in 1896. All of these were characterized as experiments, the decision stating that:

"The sidewalk construction was much the closest approximation to the invention of Warren. That Warren believed himself to be the discoverer of his composition for street paving is presumed from his oath to that effect and that presumption must stand until overthrown by very clear evidence."

"The presumption that he believed himself to be the inventor of the pavement for which he was given a patent must be our starting point in determining whether his patent is defeated by anticipation. That somebody had, in fact, made the same composition before he did does not necessarily defeat his patent. In one sense, he would not be the first inventor in such case. But in the sense of the patent statute, he is the first inventor who, by his own thought, makes an article or material and first perfects and adapts his discovery to actual use, although some one may have previously made a similar article without putting it into practical use or giving his discovery to the public in any way."

The decision continues:

"We are the more indisposed to treat this piece of experimental sidewalk as an anticipation because, in the wide range which has been covered by the evidence in this case, it has not been shown that anywhere had there been constructed a single rod of street pavement according to his plan prior to his invention. Under such circumstances, we can not think the proof of anticipation strong enough to deprive him of his invention.

"The patents relied upon as anticipations need little notice and have received little attention in briefs or arguments. Those most worthy of attention are the Van Camp and Clark provisional English specification and the British patents to Ward. They are both lamentably lacking in instruction as to the proportions of mineral ingredients of the different grades. They do propose the use of large stones and smaller ones to fill the voids together with asphalt or tar. But they do not disclose Warren's basic idea of using the several grades of stones so graded as that the stone aggregate will of itself have inherent stability which will relieve in large part the burden and strain upon the bitumen binder. Warren gives clear directions as to the construction and clearly discloses the factor of stability resulting from properly grading the mineral ingredients in excess of that found in the greater density of the sand and asphalt concrete.

"To overthrow a patent by a foreign one of prior date the description of the invention must be in such full, clear and exact terms as to enable one acquainted with the art to which it belongs to make, construct and practice the invention. Mere vague and general representations in a foreign patent will not support the defense of anticipation.

"A fatal objection to the Ward English patents is found in the fact that printed copies were not on sale prior to the actual date of Warren's invention which is clearly shown to have been made not later than January 4, 1900; the Warren patents were not published prior to October of 1900.

"The fifth, sixth and eleventh claims are infringed. The ninth is not, as it is not shown that the defendants below employed the 'comparatively soft bitumen binder,' made an element of that claim."

COST DATA ON PAVEMENTS:—BLOCK.

Report From.	Nature of Foundation.	Thickness of Foundation, Inches.	Cushion Thickenss and Character.	Make of Brick or Kind of Block.	Nature of Filler.	Approx. No. Sq. Yds.	Cost per sq. yd. Excluding Curb.
Ill., Chicago	Crushed limest'ne	8	2" sand	Metropolitan	Tar	4,900	$2.10
" "	Concrete	6	2" "	Various	Tar and grout	68,500	2.55
" "	Concrete	6	2" "	Granite block	Tar	83,700	3.89
Minn., Duluth	Concrete	6	2" "			600	2.40
[illegible]			1½" "	Sandstone block	Sand	400	-2.70
"					Cement	15,930	1.80
Mich., Gr'd Rapids	"	6	1½" "	Metropolitan brick	asphalt	1,540	1.90
" "	"	6	"	Trimble	Cement	22,300	1.80
" "	"	6	"	Medina block	"	9,930	3.85
" Kalamazoo	"	6	"	Metropolitan	Asphalt	12,000	1.94
Mont., Butte	"	4	2" "	Granite block	Sand	1,680	3.98
Neb., So. Omaha	"	5	1½" "	Purington block	Sand	34,415	[1]1.97
N. Y., Binghamp'n	"	6	1½" "	Corning shale brick	Cement	8,975	1.61
" Buffalo	"	6	1" sand or scgs.	Various	"	16,854	2.60
" " "	Macadam	12	"	"	"	2,904	3.06
" Troy	Old granite blocks relaid	8	1" sand	Johnsonburgh	"	5,277	2.30
" "	Concrete	6	1" "	Shawmut	"	396	2.32
" "	"	6	1½" "	Hassom granite block	"	6,350	3.00
" "	"	9	1½" "	"	"	6,850	3.00
N. Dak., Gr'd Forks	"	6	1½" "	Norway and Tamrack creosoted blocks	Tar	37,000	3.02
Ohio, Akron	Sand	10	2" "	Akron brick block	"	25,000	1.07
" "	Slag	8	"	"	"	10,000	1.13
" Barberton	Concrete	6	"	Metrobolitan	"	22,774	[2]1.73
" Chillecothe	"	6	1" "	Union paver	Cement	4,420	1.39
" Cleveland	Sand	.....	....	Collinw'd shale blk 5"	"	3,888	1.41
" "	"	.....	....	Bessemer 5" shale blk.	"	5,101	1.39
" "	"	8	....	Clevel'd 5" shale blk.	"	3,859	1.79
" "	Concrete	6	2" sand	Clevel'd 4" shale blk.	"	7,771	1.88
" "	"	6	"	Metro'n 4" shale blk.	"	4,094	2.17
" "	"	6	"	Bessemer 5" shale blk.	"	7,864	2.54
" "	Sand	8	....	Com. med sandstone	"	1,091	3.06
" "	Concrete	6	2½" "	" "	"	1,440	3.08
" "	Sand	8	....	Dressed block Medium sandstone	"	1,529	3.22
" Columbus	Concrete	6	1" "	Athens, Nelsonville	Tar	....	1.65
" Conneaut	"	5	Yellow sand	Conneaut	Asphalt	20,000	1.63
" Coshocton	Gravel	8	2" sand	Metropolitan	Tar	5,538	1.23
" "	Sand and gravel	0	2" "	Novelty	"	2,720	1.04
" Dayton	Concrete	6	1" "	Portsmouth, Carlyle	Cement	....	1.45
" Findlay	"	6	2" "	Massilon	"	3,676	1.65
" "	Macadam	8	"	Malvern	Tar	2,317	1.41
" Ottawa	"	7	"	Bolen block	Sand	60,000	1.25
" Newark	Gravel	8	"	"	"	5,015	1.12
" "	"	8	"	Townsend	"	4,995	.99
" "	"	8	"	Logan	"	7,938	1.07
" Springfield	Concrete	6	"	Brick	Pioneer	6,000	1.80
					Cement	2,000	1.60
" "	"	6	¾" sand & cem't	Asphalt block	Sand	6,400	1.91
" Toledo	"	6	1½" sand	Various brick	"	95,000	[3]1.30
" "	"	6	1½" cem't mort.	Asphalt block	"	12,000	1.30
" Troy	"	6	1½" sand	Townsend	Cement	38,000	1.80
" Youngstown	"	4	"	Bessemer block	Asphalt		1.28
					Cement	64,875	-1.43
" "	"	6	"	"	"	1,235	2.15
" "	"	5	"	"	"	4,630	2.13
" "	"	4	"	Asphalt block	"	4,360	1 98
Pa., Chester	"	2	2" "	Vitrified shale, brick	"	4,950	2.23
" Scranton	"	6	"	" "	Cement	3,778	2.17
" Wilkerbarre	"	6	"	Clarified Mfg. Co's brk.	"	12,000	1.97
Wis., La Crosse	"	6	"	Purington	Asphalt	3,000	1.90
D. C., Washington	Gravel	5	"	Asphalt block	Sand	26,000	1.65
W. Va., Chester	"	8	"	Fire clay brick	"	43,300	[4] .98

[1] $1 97 to 2.18. [2] $1.73 to $1 76 [3] $1.30 to $1.60 [4] $0.98 to $1 14

Water-works and Sewer Section

Note: This section is devoted to methods and costs of constructing sewers and water-works. It will cover the construction work for all details of water supply and sewerage, including sewage purification and water filtration.

Structural Details and Methods of Constructions of the Lawrence Avenue Intake Tunnel, Chicago Intercepting Sewer System.

The full development of the Chicago Drainage Canal to divert all sewage flow from Lake Michigan involved the construction of a costly system of intercepting sewers by the city of Chicago. These intercepting sewers now take the flow of all the sewers formerly emptying into the lake and divert it to the Chicago River whence it reaches the Drainage Canal. For the North Side of the city the intercepting system consists of two branches parallel to the lake shore, one carrying the flow south and the other carrying the flow north, which join at Lawrence avenue, whence a 16-ft. circular conduit takes the combined flow west along Lawrence avenue, to an outlet into the North Branch of the Chicago River. The general route of this system is outlined in Fig. 1, from which the reader can also trace the course by which the sewage finally reaches the Drainage Canal.

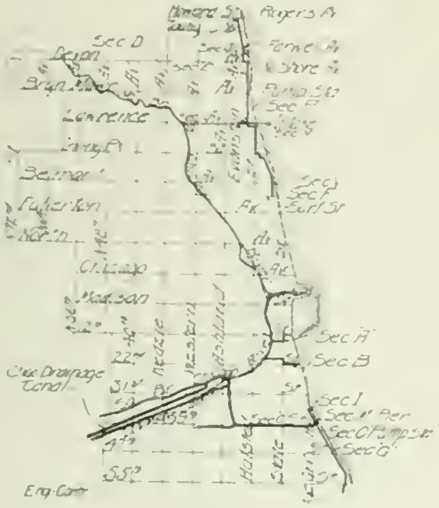

Fig. 1—Sketch Map of North Side Intercepting Sewer.

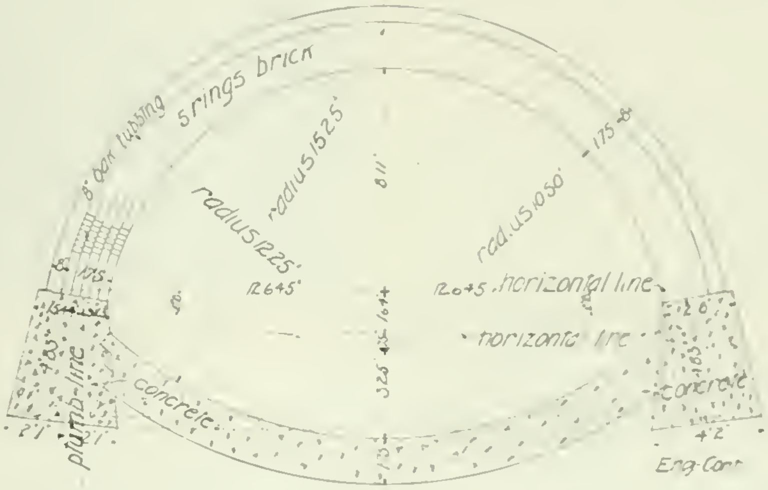

Fig. 2—Cross Section of Intake Tunnel.

The flow in the two branches of the North Side intercepting system is by gravity north and south to the junction at Lawrence and Evanston avenues and here it is received by centrifugal pumps and elevated to the level of the 16-ft. Lawrence avenue conduit running to the river. To dilute the raw sewage and provide ample volume of water to flush it down through the North Branch an intake tunnel was built east from the Lawrence avenue pumping station out under Lake Michigan to an inlet crib about 1,400 ft. from the shore. Through this inlet tunnel screw pumps draw clear lake water and discharge it into the sewage flow west through the Lawrence avenue conduit. This intake tunnel was put in operation in October, 1908, it is of particular engineering interest because

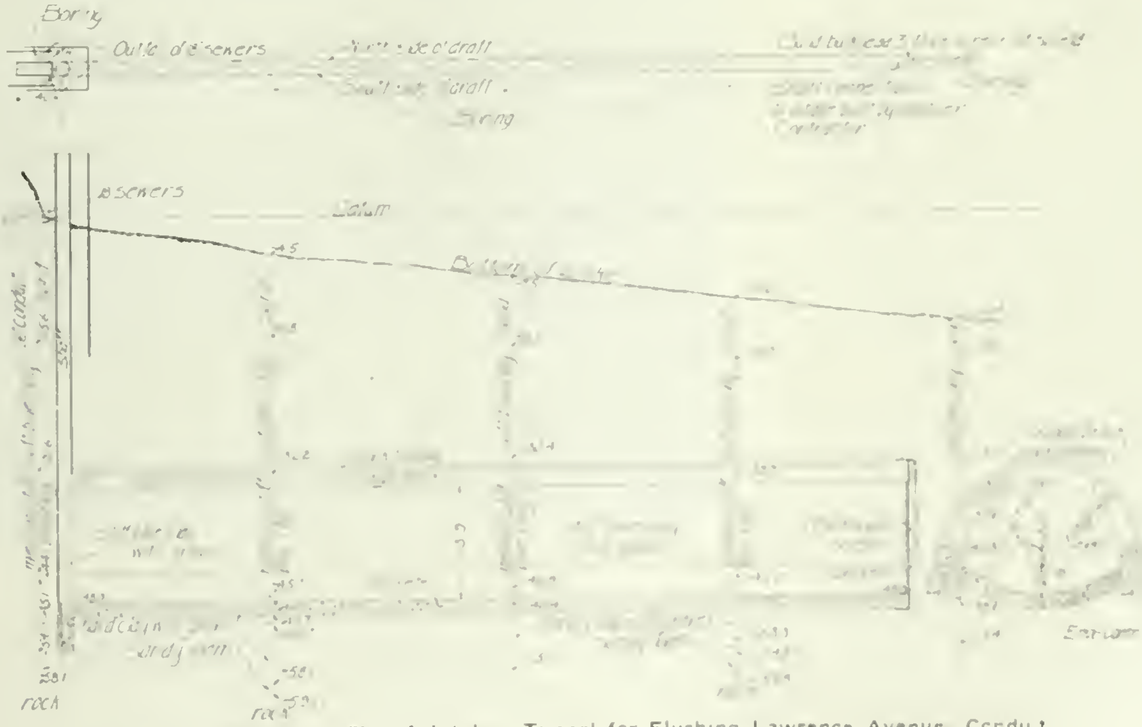

Fig. 3—Plan and Profile of Intake Tunnel for Flushing Lawrence Avenue Conduit.

of its size and of some of the methods adopted for its construction.

The choice of a tunnel instead of an open intake was determined by the hydrographic conditions. The waters of the lake are quite shallow along the north shore of the city so that at a distance of 1,400 ft. off shore there is only 30 ft. depth. Being an open shore the seas are consequently very heavy and with the ice formation in winter bring hazard to any but the most sturdy of marine structures. Borings made along the line indicated that by going to a very moderate depth a tunnel lying entirely in a stiff blue clay could be built. A tunnel was therefore decided on and its profile and section are shown by Fig. 3. Its length between center of shore and intake shafts is 1,446 ft.

The tunnel was planned originally to be entirely of concrete but it was finally decided to make the arch of 5 rings of brick. The adopted cross-section is shown by Fig 2, and the span and curve are unusual for an intake tunnel. The arch and the invert make up nearly the whole circumference, the side walls being little else than abutments for the two arches. The screw pump which the intake supplies has a capacity of 585 cu. ft. per second. Fig. 4 shows the connection between the intake tunnel and the Lawrence avenue conduit.

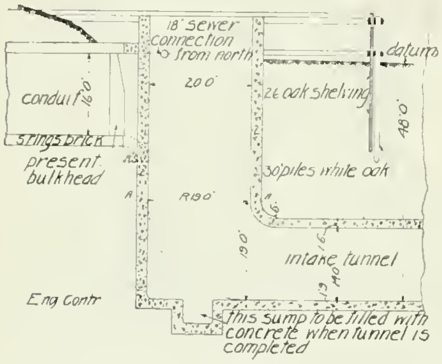

Fig. 4—Connection Between Intake Tunnel and Lawrence Avenue Conduit.

The method of driving the tunnel was to excavate two parallel side drifts and build the concrete side walls; then by means of a roof shield to take out the arch section and build the brick roof arch, and finally remove the core between side drifts and place the concrete invert. The work was carried on in one direction only, outshort from the above shafts.

The character of the drifting is indicated by Fig. 5. Each drift was 7 ft. high, 6 ft. wide at the top and 9 ft. wide at the bottom, and was through stiff blue clay which changed to hardpan at about the level of the floor of the drift. Excavation was done with draw-knives and adzes, and close timbering was employed. The drifts were run about 1,200 ft. ahead of the other work. To take out the roof arch a shield constructed as shown by Fig. 6 was used.

The shield was essentially a nearly semicircular segment of heavy steel construction, with pockets for 12 hydraulic jacks. The cutting edge was made of heavy cast steel sections securely fastened to the body of the shield. A tail piece of ½-in. steel 4 ft. long was riveted to the end of the shield; this formed a means for the building up of the timber shell of 8-in. oak against which the feet of hydraulic jacks bore when forcing the shield ahead. These compartments in the face of the shield were the working rooms for the miners who cut the stiff clay with specially designed drawing knives and deposited it in dump cars which were afterward pulled out by mules into the airlock and from thence to the hoisting shaft. As the mining progresses the timber men keep building up the oak ring behind the jacks and when the miners have excavated to the cutting edge, the shield was forced ahead about 20 ins. by the hydraulic jacks; then the operation was repeated. The brick layers followed perhaps 50 or 60 ft. behind the shield and put in the five ring brick arch resting on the two side walls and finally the invert was excavated and concreted.

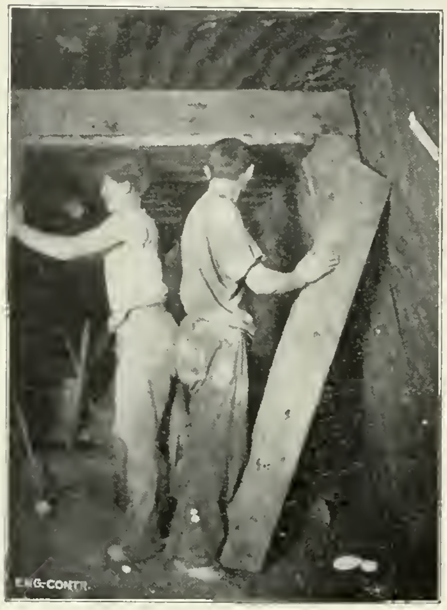

Fig. 5—View Showing Timbering of Drifts for Side Walls.

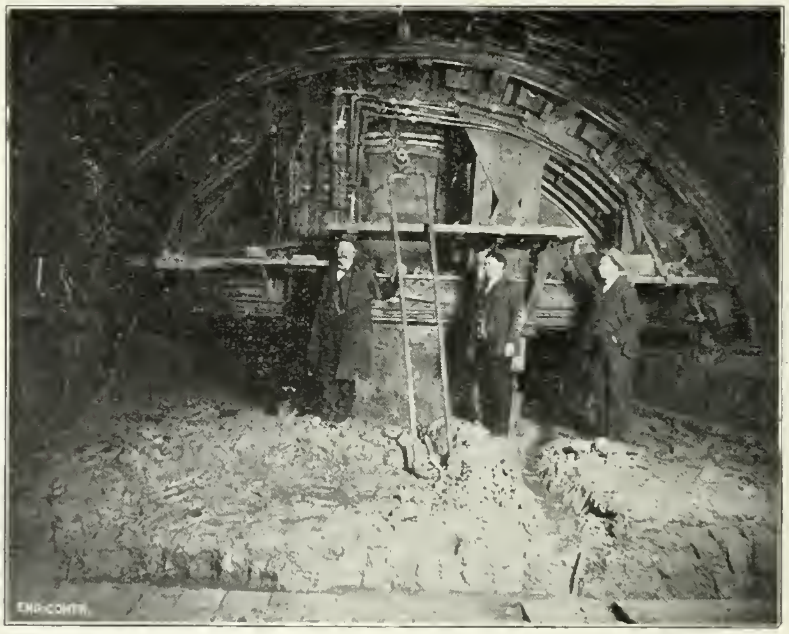

Fig. 6—View of Rear End of Roof Shield Showing Timber Lining.

The operation of the shield calls for no special mention. A Knowles pump supplied the jacks with a pressure of 3,000 lbs., through a pipe hung from the crown of the arch and running from shaft head to shield. At the shield the connection with the valve board was made by a double swinging joint which permitted the shield to be advanced several feet without changing the connection. The shield traveled on four 90-lb. rails, two on each side, resting on a 4x14-in. oak timber on the side walls.

After the first 50 ft. of tunnel was completed an air lock was constructed and all the remaining work was done under an air pressure of about 8 lbs. per sq. in. The use of a timber lining to take the thrust of the jacks operating the shield was somewhat unique; it proved successful. This timber shell was made up of 3 and 4-ft. segments cut from 7x10-in. oak timbers, at a saw mill on the job. The segments were set close, and stood up with very slight settlement of the arch. The brick arch was built in 22-ft. sections using a traveling center which ran on rollers and had clearway for the material cars. Three shifts were worked, each consisting of about 40 men.

The contractor for the work was the M. H. McGovern Co., of Chicago, Ill. The engineers were: John Ericson, City Engineer, Wm. S. MacHarg, Consulting Engineer, and R. A. Bonnell, Assistant Engineer in charge.

Bridges, Buildings and Foundations

Note: This section is devoted to methods and costs of constructing steel and masonry bridges and buildings and of foundation work of all kinds. It will give special attention to erection plant and tools, falseworks and centers and cost data of all kinds.

Methods and Cost of Constructing a Plate Girder Bridge With Concrete Piers.

The bridge consists of 17 spans of 50 ft deck plate girders carried on concrete piers and reinforced concrete abutments. The substructure is founded on solid rock ranging in depth below low water from zero on the west shore to 19 ft. on the east shore. The west abutment and succeeding 13 piers were carried to rock; the three remaining piers and the east abutment were set on piles driven to rock and cut off at low water level. The piers consists of bases 14 ft. 9 ins. x 7 ft. 9 ins. in dimensions and varying in height with the depth of foundation, and shafts 13 ft. 9 ins. x 6 ft. 9 ins. at the base; 12 ft. x 6 ft. at the top over coping and 28 ft. high. Each shaft contains about 84.8 cu. yds. of concrete. The spans between pier centers are 50 ft. 3 ins. The abutments are of reinforced concrete.

Two methods of construction were employed. The first method was used for the west abutment and the succeeding six piers. Operations were conducted from the river bed. The west abutment was above water level and was straightforward construction. For this six succeeding piers U. S. Steel Sheet Pile cofferdams were built and excavated; the base forms were set inside and concreted, and then the shaft forms were erected and concreted. A 60 x 120 x 4 ft. barge in the river carried a hoisting engine and stiff leg derrick. This derrick handled the forms and also a clam shell for excavating the cofferdams. A pile driver supported on heavy horses drove the sheeting. The concrete was mixed on the river bed by a ½ cu. yd. Chicago Improved Tube mixer and taken to the work in dump buckets in push cars running on a track which was extended from pier to pier. At the piers the buckets were raised and dumped by means of a mast and boom head. When the pier was completed the girders were set by means of a 15 ton derrick car.

Work was conducted in the manner described from April 20, 1907, to May 1, 1908. This slow progress was due largely to the fact that the organization was such that one part of the work had to await the completion of another, no two operations being carried on at the same time. Furthermore the driving and pulling of the steel sheeting was a tedious process. It took from a week to ten days to drive the sheeting for one cofferdam, and in penetrating the cemented gravel the piles were often so battered and bent that it took as long or longer to pull as to drive them. The excavation of the cofferdam occupied about two days. It was to remedy this slow progress that the second method of construction was devised by Mr. W. W. Colpitts, Assistant Chief Engineer, who assumed personal charge of the work.

A second track was laid parallel to the main track as shown by Fig. 1. To support this second track 20 ft. guard rail timbers were inserted between each pair of main track ties and secured with hook bolts to the girder flanges. On the overhanging ends of these timbers two lines of 3 x 12-in. planks, on 5 ft. centers, were laid to carry the second track rails. The concrete mixer was removed from the river bed and placed on the west bank as shown by Fig. 1; the second track led directly to and from the mixer. A siding was also laid to the mixer for the sand and gravel cars, which were loaded at a nearby cutting. Water was pumped to the mixer from the river as shown by Fig. 1.

The second track was extended from pier to pier as fast as the main track was completed, so that the derrick car could be run out on the second track to a position alongside the last completed pier. The derrick car boom was lengthened about 25 ft. by bolting and trussed with wire cables to sustain a load of 4 tons at its outer end. From the boom a 60 ft. extension of the second track was suspended by cables at the outer end and at mid-length; the inner end of the extension track was supported by a bent on the pier. The arrangement of the extension track is made clear by Fig. 1. As will be seen the concrete could come from the mixer by car to directly over the pier. When a pier had been concreted the extension track was set one side and detached and the derrick was available for erecting the plate girders.

For depositing concrete below water a bucket was devised to operate with a single line, as illustrated in Fig. 2. It was built of a 3 ft. section of 36 in. corrugated iron culvert pipe, having a capacity of ½ cu. yd. In the bottom, which was of wood, was a flap valve 8 ins. square, opening upward. A 1-in. iron trunnion set 6 ins. off center, was secured to the bottom. A bale with chain hooks at its extremities was attached to the pile line of the derrick car which was led through a block at the end of the boom directly over the center of the pier. To the top of the bale was pivoted a counter-weighted trip engaging a lip on the side of the bucket. The bucket was carried on a push car and the mixer discharged directly into it. It was then run out to the end of the extension, the hooks of the bale slipped over the trunnions, the trip caught on the lip, the bucket raised, and the car pushed from under it. The bucket was then lowered and upon its weight being taken on the bottom the trip automatically released. As the bucket was slowly raised from the bottom it upset, the valve in the bottom opened and the concrete poured out without disturbance, its construction being such that it discharged toward the lowest point. Three buckets were used, one being dumped while two others were on their way to and from the mixer, the loaded car using the second track, the empty car returning on the main track.

The concrete for the shafts was carried in dump boxes on push cars, Fig. 3. The forms were securely wired to prevent distortion from the falling concrete and baffle boards were used to distribute the concrete uniformly.

It was found that detachable cast steel teeth on the lips of the clam shell greatly

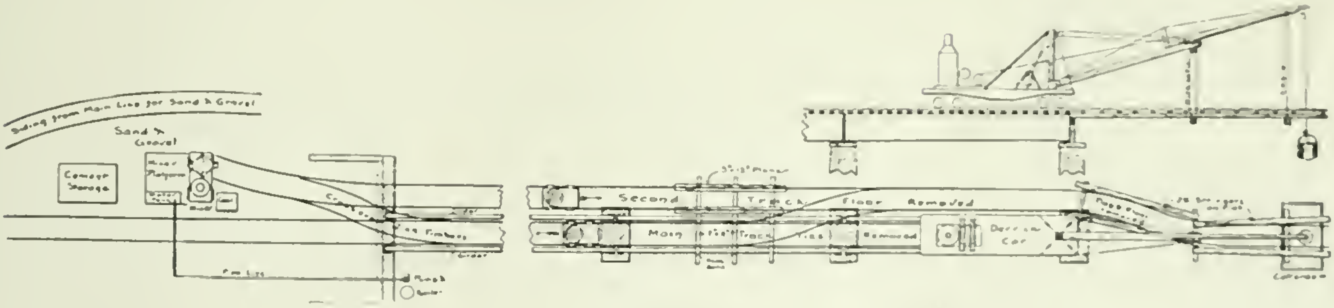

Fig. 1—Plant Lay-Out for Constructing Concrete Bridge Piers.

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*Rearranged from an article by W. W. Colpitts, M. Am. Soc. C. E., in the "Railroad Age-Gazette" of Jan. 22, 1909.

increased the daily capacity of the dredge and this fact suggested the advisability of doing away entirely with the steel sheet piling which had proven both expensive and slow. The greatest depth to rock was 19 ft. below the low water surface and was practically level over the area of a pier. It was decided to sink open wooden cofferdams, first dredging as deep as practicable in the open water at the pier site, the limit of which proved to be about 12 ft. In the meantime, the timber for the cofferdams was being framed on the bank. They were built as follows: The three bottom courses were composed of condemned bridge stringers, the lower one having a 45° cutting edge, unshod. Above the stringers the sides were composed of 3 x 12-in. plank, spiked to corner posts and studs.

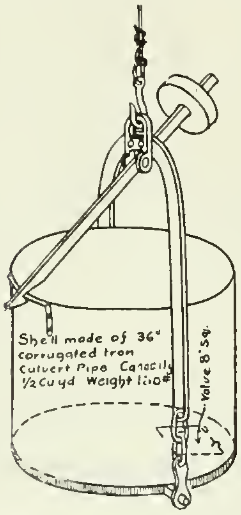
Shell made of 36" corrugated Iron Culvert Pipe Capacity ½ Cu yd Weight 150#
Valve 8" Sq.

Fig. 2—Bucket for Depositing Concrete Under Water.

During construction the cofferdam was supported on a raft also composed of condemned bridge stringers. The raft was built with an open bay, about 1 ft. larger on all sides than the cofferdam. Across the center of the opening was stretched a heavy telegraph wire supporting the ends of four planks, the other ends resting on the raft. The lower courses of timbers of the cofferdam were then set in position on these planks and drift-bolted together. The position of the cofferdam on the planks was such that only a small percentage of its weight came upon the wire. The two other courses of stringers were then laid and bolted and the corner posts and studs bolted to these, after which the 3-in. planks comprising the balance of the sides of the cofferdam were spiked to the corner posts and studs. When completed, the wire was cut and the cofferdam launched into the water below, which, as stated above, had previously been dredged to a depth of about 12 ft. It was then guyed to its exact position and held level by lines from the boom of the barge derrick. Four posts or legs, with the lower ends resting on the bottom of the excavation, were spiked to the outside corners and all the guys removed, allowing the cofferdam to rest entirely upon these legs. To make provision for weighting the cofferdam while being sunk, stringers were placed across its ends and on the portions projecting beyond the sides, a floor of other stringers was laid and boxed up to a height sufficient to carry a load of about 75 tons of gravel each. The dredging operations were then begun and the material taken from the interior of the cofferdam placed in the boxes until they were filled. When the dredging had continued to a point where the bearing was uniform on the cutting edge of the bottom, the legs detached themselves from the sides and floated to the surface.

By carefully sounding the bottom and loading the boxes uniformly as the dredging proceeded, the cofferdam sank uniformly to the rock. The load was not removed from the boxes until the concrete had been placed, when by cutting the wires supporting the sides the gravel dropped into the water. The cofferdam was prevented from bulging when the concrete was being deposited, by means of a wire cable strung around the top and wedged taut at each of the studs. The derrick car was not removed from its position supporting the extension track until the concrete in both the base and shaft had been placed. The pile line of the derrick car was, therefore, available in removing the form on the shaft of the pier behind and erecting it on the recently completed base. The operation of filling it with concrete was then begun. While the work of placing the concrete in the base, erecting the form for the shaft, filling it and setting the girders was going on, the barge was employed in dredging for and sinking the next cofferdam, and in this manner the work proceeded until the 13th pier was completed.

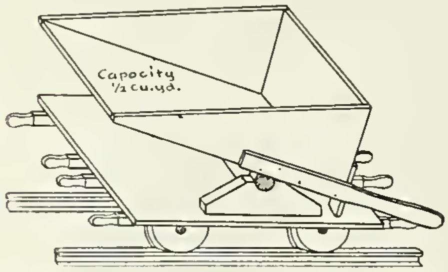

Fig. 3—Dump Box on Push Car for Transporting Concrete.

The piles in the foundations of the three piers on the east bank of the river were driven with rail leads suspended loosely from the boom of the stiff-legged derrick, which had been removed and placed on skids on the bank. The forms were set and filled in the manner described.

The method of building the west abutment was as follows: Upon the completion of the excavation, the form was built up to a point 3 ft. above the bottom of the overhang. The piles were then driven and the back-filling completed up to the level to which the form had been built and care taken to tamp the filling solidly under the form for the overhang. The form was then filled with concrete to the top and the overhanging slab, which was 3 ft. thick, reinforced with steel to enable it to support the load of green concrete that would later come upon it. The form for the upper portion was then completed and the whole filled with concrete up to the bridge seat in two days' run. The west abutment was completed and the last span set on August 27, 1908, an average, after May 1, of one pier and span about every nine working days.

The statement of cost will be especially interesting to those who are familiar with conditions in the Republic of Mexico. Generally speaking, machinery, materials and supplies of all kinds are much more costly than in the United States, but this disadvantage is partly offset by cheap labor. The scale of wages (in U. S. currency) that prevailed on the work are given below:

General foreman	$150.00 per month
Sub-foremen	4.00 per day
Hoisting engineers	4.00 per day
Firemen	1.50 per day
Carpenters	1.50 per day
Blacksmiths	2.00 per day
Laborers (peons)	.75 per day

The cost of materials delivered at the work was as follows:

Cement, per bbl.	$ 3.73
Form lumber, per M. ft. B. M.	23.33
Bridge timber, per M. ft. B. M.	36.65
Reinforcement, per ton	79.20
Steel sheeting per ton	54.15
Bridge Steel, per ton	69.98

In the statement below a proportion of the cost of all machinery and tools is charged against the bridge, depending upon their condition and availability for future work.

ABUTMENTS.

(Contain 586.2 cu. yds. concrete.)

Material:	Total.	Per cu yd.
Cement, 694.4 bbls., at $3.73	$2,590.11	$4.42
Sand, 263 cu. yds., at $0.50½	132.81	0.23
Gravel, 526 cu. yds., at $0.50½	265.62	0.45
Lumber, 22,232 ft., B. M., $23.33	518.66	0.88
Piles, 240 lin. ft., at $0.22	52.80	0.09
Reinforcement, 41,730 lbs., at $3.96	1,632.51	2.79
Machinery, proportionate cost	59.21	0.10
Wire and nails	101.50	0.18
Lubricating oil	6.50	0.01
Fuel	109.00	0.18
Total material	$5,468.72	$9.33
Labor:		
Excavation for foundation	$ 199.66	$0.34
Building and removing forms	331.01	0.57
Driving piles in foundation	67.77	0.11
Placing steel reinforcement	92.55	0.16
Mixing concrete	220.53	0.38
Placing concrete	96.39	0.17
Pumping water	18.74	0.03
Cleaning and storing machines, etc.	61.00	0.10
Total labor	$1.087.65	$1.86
Total material and labor	$6,556.37	$11.19

BASES OF PIERS 1 TO 16, INCLUSIVE

Bases 1 to 6 contain 373 cu. yds.
Bases 7 to 16 contain 887.7 cu. yds.

Total ....1,260.7 cu. yds.

			Total	cu. yd.
Material:				
Cement, 1,233 bbls., at $3.73			$4,599.09	$3.65
Sand, 591 cu. yds., at $0.50½			298.46	0.24
Gravel, 1,182 cu. yds., at $0.50½			596.92	0.47
Cofferdams of piers 1 to 6				
Lumber, 3 M., B. M., at $23.33	$ 69.99			
Steel sheet piling	924.72			
Wire nails and oil	53.00			
Machinery	817.00			
Fuel	700.00			
Material in cofferdams 1 to 6		$2,564.71		
Per cu. yd. concrete in bases 1 to 6	$ 6.88			
Cofferdams of piers 7 to 16:				
Lumber, 26 M., B. M., at $23.33	$606.58			
Piles in foundation	198.00			
Wire nails and oil	210.25			
Machinery	1,353.66			
Fuel	1,200.00			
Material in cofferdams 7 to 16		$3,568.49	6,133.20	4.86
Per cu. yd. concrete in bases 7 to 16	$4.02			
Total material			$11,627.67	$9.22
Labor:				
Mixing concrete			580.33	0.46
Placing concrete			662.26	0.52
Pumping water			38.00	0.03
Cleaning and storing machines, etc			122.01	0.10
Cofferdams of piers 1 to 6:				
Excavation	$ 857.22			
Driving sheet piling	1,653.19			
Pulling sheet piling	371.60			
Building inside forms	214.21			
Labor on cofferdams 1 to 6:		$3,096.22		
Per cu. yd. concrete in bases 1 to 6, $8.30.				
Cofferdams of piers 7 to 16:				
Excavation	$1,010.05			
Piles in foundation	313.23			
Building and sinking C. dams	870.89			
Labor on cofferdams 7 to 16		$2,194.17	5,290.39	4.20
Per cu. yd. concrete in bases 7 to 16, $2.47.				
Total labor			$6,692.99	$5.31
Total material and labor			$18,320.66	$14.53
Labor and material of cofferdams, 1 to 6, per cu. yd., concrete				$15.18
Labor and material of cofferdams, 7 to 16, per cu. yd., concrete				6.49

SHAFTS OF PIERS, 1 TO 16, INCLUSIVE.

(1,357.2 cu. yds. concrete. The shafts of the piers did not differ appreciably in cost, and the statement is not divided as in the case of the bases.)

	Total.	Per cu. yd.
Materials:		
Cement, 482 bbls., at $3.73	$4,617.74	$3.41
Sand, 257 cu. yds., at 50½ cts	321.69	0.24
Gravel, 514 cu. yds., at 50½ cts	643.38	0.47
Lumber, 3,000 ft., B. M., at $23.33	163.31	0.12
Machinery, proportionate cost	155.00	0.11
Wire and nails	101.50	0.07
Lubricating oil	28.50	0.02
Fuel	919.00	0.68
Total material	$6,950.12	$5.12
Labor:		
Building and removing forms	$582.55	$0.43
Mixing concrete	602.45	0.45
Placing concrete	652.79	0.48
Pumping water	39.00	0.03
Cleaning and storing machinery	122.01	0.09
Total labor	$1,998.80	$1.48
Total material and labor	$8,948.92	$6.59
Total cost of substructure	$33,825.95	$10.56

STEEL SPANS—17 50-FT. DECK PLATE GIRDERS

	Total.	Per ton.
Material:		
Steel, 611,734 lbs. f. o. b., New York	$16,822.68	$55.00
Freight and brokerage	4,582.08	14.98
Fuel, setting and riveting girders	181.36	0.59
Total material	$21,586.12	$70.57
Labor:		
Unloading and setting girders	$294.43	$0.96
Riveting girders	640.37	2.09
Setting anchor bolts	105.00	0.34
Machinery, proportionate cost	253.70	0.83
Total labor	$1,293.50	$4.22
Total material and labor	$22,879.62	$74.79

DECK—TIES L. L. P. 8-IN. X 10-IN. X 10-FT., SPACED 13 IN. CENTERS. GUARD RAILS L. L. P., 7-IN. X 9-IN. X 20-FT.

	Total	Per M. B. M.
Material:		
62,401 ft., B. M., f. o. b., Safton, La	$1,123.22	$18.00
Freight and brokerage	1,163.78	18.65
Fuel	25.50	0.40
Total material	$2,312.50	$37.05
Labor:		
Framing and placing	$561.68	$9.00
Machinery, proportionate cost	60.63	0.97
Total labor	$622.31	$9.97
Total material and labor	$2,934.81	$47.02
Total cost of superstructure	$25,814.43	..
Total cost of bridge	$59,640.38	..

Cost of a 300 ft. Highway Drawbridge.

A highway drawbridge across the Harlem River at 3d Ave., New York City, was begun in 1893 and finished in 1898. The span is 300 ft. long; the width is 87½ ft. over all. There are four lattice trusses. The three carriage ways are each 20 ft. wide, and the two sidewalks are each 9 ft. wide, carried on cantilever brackets. The floor is of buckle plates covered with concrete and asphalt pavement. The bridge weighs 2,500 tons, and is carried on a 60 ft. turntable. The time required for a full opening is 2 mins. and 2 mins. more for closing and locking. A 50 HP engine does the work, but a duplicate power plant is provided.

The contract price was $1,111,000 for the bridge complete, which is $47 per sq. ft. of roadway and sidewalks. The total cost, including lands, was more than $2,000,000.

The following are some of the important quantities and bidding prices:

	Unit prices.
107,500 ft. B. M. yellow pine in temporary bridge	$40.00
200,000 ft. B. M. hemlock in temporary bridge	30.00
5,000 cu. yds. pneumatic caissons including concrete filling	20.00
Portland cement concrete, cu. yd.	9.00
Natural cement concrete, cu. yd.	5.40
Granite Ashlar facing below low water, cu. yd.	11.00
Granite Ashlar facing above low water, cu. yd.	20.00
Granite caps, cu. ft.	2.50
Granite coping, cu. ft.	3.00
Granite columns, capitals and bases	2.00
Granite dimension, in rough bases	0.50
Rough pointing, sq. ft.	0.10
Fine pointing, sq. ft.	0.50
Four-cut axing, sq. ft.	0.50
Six-cut axing, sq. ft.	0.60
Eight-cut axing, sq. ft.	0.70
382,000 lbs. rolled steel and iron in turntable	0.045
1,692,000 lbs. rolled steel and iron in draw span	0.039
1,486,000 lbs. rolled steel and iron in deck spans	0.037
1,200 lbs. corrugated plates deck spans	0.031
357,000 lbs. buckle plates, draw spans	0.032
282,000 lbs. steel plate girders	0.033
120,000 lbs. steel rolled beams	0.026
117,800 lbs. castings in wheels	0.07
126,000 lbs. castings hub and shell plates	0.07
2,000 lbs. other iron castings	0.025
75,000 lbs. steel plates or angles	0.02

In making a cut through the old line of the Panama R. R. on the Isthmus, a 20-in. suction dredge encountered piles that were completely rotted down to sea level, but below sea level were as full of pitch and as sound as when driven 60 years ago.

The production of bituminous coal in the United States in 1908 amounted to 325,750,000 tons.

Materials for a Caisson.

In building a single track bridge for the Illinois Central R. R. across the Ohio River near Cairo, 10 piers were sunk 75 ft. below low water. The frictional resistance was found to be 600 to 700 lbs. per sq. ft. of exposed surface. The largest caisson and crib is 30 ft. wide, 70 ft. long and 50 ft. high. The total height of the pier is 177 ft. (50 ft. of caisson and crib filled with concrete, and 127 ft. of masonry on top). It contains the following materials:

331,000 ft. B. M. lumber.
137,000 lbs. iron.
2,865 cu. yds. concrete in caisson and crib.
3,800 cu. yds. masonry.

The pier measures 14x43 ft. on top.

The weight of the 137,000 lbs. of iron was distributed as follows:

	Lbs.
Cutting edge	26,583
Corner plates	8,108
Air locks (1 pr. doors left in)	7,287
Sections of shaft	14,813
Rods	30,570
Washers	7,111
Drift bolts	21,606
Boat spikes	15,402
Lag screws	265
Bolts	331
Pipe (334 ft. of 4 in.)	3,495
Pipe (83 ft. of 5 in.)	1,234
Total	136,785

Weight of a Steel Viaduct.

A single track steel viaduct was built in 1904 near Paoli, Ind., for the Chicago, Indianapolis & Louisville Ry. It is 870 ft. long, and 87 ft. high in the center. It has 2 abutments and 36 small pedestal piers, four under each tower. The abutments are 60 ft. high. The pedestal piers are 3½ ft. square on top and extend down to solid rock, a distance of 3 to 12 ft. below the ground. There are 4,300 cu. yds. masonry in piers and abutments, and 1,091,000 lbs. steel and cast iron in the viaduct.

The First Iron Railway Bridge.

In the Railway Gazette, July 8, 1904, is illustrated and described the "first iron railway bridge." It was built in 1823 for the Stockton & Darlington Ry., at West Auckland, England. It was really a trestle with cast iron posts, and four iron spans of 12 ft. 8 ins. each. The spans consisted of double arch members of wrought iron united by cast iron struts. The bridge was removed after 80 years of service.

During the calendar year 1908, awards to the amount of $13,421,752 were made for work on the New York State Barge Canal. There are now in force contracts for building 194 miles of canal, the contract price for these being $35,739,213, including all alterations to date.

Unclassified and General Articles

Note: This section is devoted to methods and cost articles on construction work not properly coming under any of the preceding classifications.

Suggestions for Drawing Specifications for Engineering Work.*

[Though addressed to British engineers the following criticisms and suggestions on the writing of specifications are just as pertinent when addressed to American engineers. The specification which stands free from all of the faults cited by Mr. Butler is a rare document in the engineering practice of any country, yet none of these faults is difficult to correct if the time and study necessary are taken by the engineer. We commend to particular attention the remarks on such familiar clauses as, "The work shall be done to the satisfaction of the engineer"; on copying paragraphs and sections from old specifications; on definiteness of statement; on key plans showing the contractor the local conditions likely to affect the cost of the work, and, finally, on the importance of the engineer knowing what he is talking about.—Editors.]

The preparation of a specification, as a preliminary to entering upon a contract of engineering works, is unquestionably one of the most important of an engineer's duties, requiring very complete experience and thorough technical knowledge for its satisfactory accomplishment; yet some specification writers display a fine disregard of the true function of such a document, and show a childlike faith in the ability and generosity of the contractor, which, although very flattering to him, does not say much for the business instinct of its professors.

In this paper some of the points that are essential to the production of a specification which shall properly fulfill its purpose are touched upon, and this purpose is to amplify the contract drawings by giving detailed descriptions of the materials to be used, the methods of preparing and using them, and other information which cannot be conveniently written on the drawings themselves. The two main divisions of an ordinary specification are the conditions of contract and the specification, properly so-called. The form of tender is not infrequently attached.

The conditions of contract, as their name implies, form the legal part of the document, as distinct from the technical description of work to be done, but it cannot be too clearly borne in mind that the whole of a specification, when duly signed by the parties to the contract, is a legal document which must be produced in court if a dispute should unfortunately arise with reference to the works; and it is, therefore, of the utmost importance that it should be lucidly written in simple language, the clauses being arranged in logical sequence, and the description exact and complete without being needlessly verbose. Every item of work should be allotted a separate clause, for when a single clause includes descriptions of several different matters confusion must ensue.

A complete alphabetical index, with the clause and page numbers attached, will be found to be (especially in the case of a lengthy specification) a great help in quickly finding any required subject, and cross references may sometimes be introduced with advantage.

Brevity, so far as it is consistent with completeness, being the hall-mark of a good specification, no information should be introduced which may be clearly obtained from the drawings, the intention being that the drawings and specification are to be taken together, and a clause to this effect is sometimes inserted. On the other hand, it is waste of labor, besides being confusing, to put descriptive matter on the drawings which would be better included in the specification; and a mistake which is frequently made is to duplicate information in this way, obscuring the drawings with unnecessary writing, and overloading the specification with identical information.

A very common fault in specifications is indefiniteness of description, and this generally arises from the writer not having a clear notion of the work or materials which he attempts to describe, though in some cases it is due to the obscurity of the language or to the misuse of certain words, especially "proper" and "sufficient." The engineer should know what is proper and sufficient, and should describe it in precise terms, otherwise he is only opening the way for trouble when it becomes necessary to find the meaning of these words in terms of actual materials and workmanship. The word "etcetera" should be rigidly excluded, and the matters covered by it clearly defined.

It should be hardly necessary to say that the drawings must be completed and inked in before the specification is written, or at all events before it is finally completed, as any other procedure will almost inevitably lead to more or less important omissions, with the result that "extras" will be writ large in the contractor's little bill. It is an advantage, when time permits, to have the detail drawings (if any) completed at this stage, as it is not unusual for important modifications to be found necessary when the details are got out on a larger scale. The drawings should, of course, be numbered, dated, in-

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*A paper by H. Laurence Butler, read Jan. 7, 1909, before the Civil and Mechanical Engineering Society, Great Britain.

initialed by the draughtsman, and signed by the engineer, and it may sometimes be useful to have reference letters or numbers on certain portions of the drawings, which may be alluded to in the specification.

An inexperienced writer of specifications is very apt to be uneven in his description of the work, writing with unnecessary verbiage on those matters with which he is familiar, and dismissing some equally important point with a brief direction that "the work shall be done to the satisfaction of the engineer." A general direction of this kind usually implies that the engineer does not know what he wants, and therefore leaves the matter to the superior knowledge of the contractor—an attitude not very creditable to the former.

The only really legitimate use of this phrase is in a general clause referring to the whole of the works. An example of uneven description within the knowledge of the author exists in the specification for certain works of sewerage, in which the tests for Portland cement occupy a half-page of closely printed foolscap. None of the tests was applied, and apparently they were not intended to be applied, but the whole description was taken en bloc from another specification, presumably with a view to overaweing the contractor. In the same specification the description of some pumping machinery at the disposal works appears to have been copied direct from the estimate of a firm of mechanical engineers, only the prices having been left out, and the curious commercial brevity of the phraseology, comprising such phrases as "including all necessary fittings complete," stands out in striking relief from the rest of the document.

It is evident, then, that one of the most essential qualifications for a specification writer is a thorough knowledge of his subject, and he should have also a sufficient command of the English language to enable him to express his meaning clearly and tersely. It is quite unnecessary to indulge in legal jargon and high-sounding phrases which the writer possibly does not understand, and it is by no means a fault to repeat words again and again if they express the meaning of the writer more clearly and forcibly than an alternative phrase would do. A specification is seldom judged by literary standards of excellence.

It is also necessary that the specification writer should have a thorough knowledge of trade customs, such as discounts (in order to define "prime cost"), the methods of measuring timber and scantlings, the different modes of dressing masonry work, whether the word "best" applied to certain materials will really mean best, or if by trade custom it may be taken to mean an inferior quality. Moreover, in the case of structural work, he should make himself acquainted with the regulations in force in the district in which the building is to be erected, and should make it clear in the specification if the contractor is to take the responsibility of complying with the local authority's requirements or otherwise.

Another error which may occur through inexperience is that of specifying impracticable sizes of materials, such as timber and metals, and this may also occur when clauses are copied from obsolete or badly written specifications. The method of compiling a specification on the "scissors and paste" principle, by taking clauses from old specifications, is one that will lead an inexperienced writer into error more quickly than any other, because if he has any doubts as to the reliability of the description, it will be more or less discounted in his mind by the fact that the particular clause has been used before, regardless of when or under what circumstances it was used.

The degree of detail which a specification should contain is governed very largely by the magnitude and importance of the work, as it is obvious that the detail in the specification for a £50,000 contract would be merely a display of misdirected energy if applied to the specification of works costing, say, £500.

A practice which should be studiously avoided wherever possible is the specifying of alternative workmanship and materials. It is far better to be exact in defining what is to be done or supplied, because it then affords no ground for dispute or difference of opinion. However, with regard to the actual methods of carrying out the work, the contractor should not be tied to any particular means of effecting the required end, unless special circumstances require it, for, provided the materials and workmanship are satisfactory, it is better to allow the contractor to use his own discretion as to the manner of producing the required result.

The arrangement of a specification is generally as follows:

(1) Conditions of contract and general regulations applying to the whole of the works.

(2) General description of materials and workmanship, excluding purely local or particular directions.

(3) Detailed description of the various portions of the work, systematically arranged.

The conditions of contract usually begin with a definition clause, which, in order to obviate needless repetition, defines such words as "employer," "engineer," "contractor," "prime cost," and similar matters. Other clauses enumerate the conditions to be observed in carrying out the works, and make the contractor responsible for giving notices required by the local authority, require him to sign the drawings and specifications within a given time from the acceptance of his tender, to provide sureties for the satisfactory completion of the work, and to commence the work within a stated period after receiving notice from the engineer to do so.

A very useful clause is that empowering the engineer to vary or alter any part of the works without vitiating the contract, and a clause requiring the contractor to render weekly accounts in writing of all extra work ordered, and particulars, greatly assists the engineer in knowing what payments may be made from time to time on account of work done, as well as in the final adjustment of accounts.

Other clauses may refer to the method of ascertaining prices for extra work, the power of the engineer to take samples for testing purposes, the covering up of work for inspection, the prohibition of assignment or sub-letting of the contract, responsibility for accidents, time for completion, period of maintenance, suspension of works through various causes, mode of payment, engineer's certificate of completion, and other matters of this nature, the conditions usually concluding with a clause providing that all disputes may be referred to an arbitrator for settlement.

It is not unusual, however, to have, in place of the arbitration clause, a condition that the engineer shall have the exclusive right to authoritatively determine the meaning of the contract. Such a provision is perhaps, rather unsatisfactory from the standpoint of the contractor, who may be inclined to consider the engineer unsuitable to act in this capacity by reason of the fact that the latter has generally formed an opinion on any dispute which may arise before the matter is referred to him for settlement; but unless it could be demonstrated that the engineer's opinion was not open to argument or reconsideration, or that he had deliberately shown prejudice or partiality, the courts could scarcely be persuaded to declare that he was unfit to be arbitrator. The chief advantage of the clause, from the engineer's point of view, is that it supplies a summary means of remedying the faults and supplying the omissions in a badly drafted specification. It would appear that the arrangement most satisfactory to all parties is for the engineer to have the final decision as regards workmanship and materials, and to provide for appeal to an external arbitrator on all matters relating to payment, such as the amount of extra works, loss to the contractor through delay or alteration of the works, and similar questions. A further modification of this provides that no appeal to an outside arbitrator shall be made during the progress of the works, but that disputes on any matter arising out of the contract shall be temporarily decided by the engineer, and his decision shall be binding on all parties until the completion of the works, after which the matter (unless expressly reserved for the final and binding decision of engineer, without appeal) may be brought before a referee. This arrangement is designed to prevent any disputed matters from causing delay in the execution of the works.

In alluding to the drawings, it is a good plan to add a paragraph to the effect that figured sizes are to be followed in preference to the scale dimensions, except in cases of obvious clerical error. The clauses enumerated above do not by any means exhaust the list of provisions that it may be necessary to make in the case of a large contract, and in very small works some of the clauses may be reasonably omitted, but they are mentioned as being generally applicable to contracts of moderate size.

The specification proper usually begins with a description of the site of the works, specifying any unusual features which may exist; and if the site is very inaccessible, involving a great deal of haulage work, it is an excellent thing to provide a key plan, showing the distance from the nearest station, and marking on it any unusually steep hills, bad roads, or other circumstances likely to affect the cost, although some engineers prefer to let the contractor find out all these things for himself, and insert a clause in the conditions to the effect that "the engineer cannot be held responsible for any incorrect information supplied."

The next clause generally enumerates the drawings, giving the number and title of each one, with the words, "and such further detail drawings as may be supplied by the engineer to the contractor from time to time." Then follows the description of materials and workmanship applying to the whole of the works, and including such matters as cement, sand, mortar, concrete, bricks, brickwork and the like, leaving the particular description of the individual parts of the work to be dealt with later.

The general description may conveniently conclude with a clause requiring the contractor, before commencing the work, to deposit with the engineer a sample of each kind of material intended to be used, all materials employed in the execution of the works to be equal in quality to the samples so deposited.

The remainder of the specification consists of detailed descriptions of the different parts of the work, subdivided under general headings. For instance, in the case of a new road and sewer, the first part would be headed "sewers and manholes," and the first clause would deal with "excavation," followed successively by "timbering," "filling in," "concrete pipe laying," "brickwork," "manhole covers," and so on. The next general heading would be "roads,' and the headings of the clauses would follow some such order as "excavation," "foundations," "hard core," "kerbing and channelling," "metalling," "grouting and rolling," "footpaths," etc.

A systematic arrangement of this nature tends to exclude the probability of any serious omission, and assists any subsequent reference to the specification. Printing a brief note of the contents of each clause on the margin of the page is a convenience when it is desired to refer to any particular item, but it should be made clear that these marginal notes are merely auxiliaries, and do not form part of the specification any more than the index does.

Another arrangement is to divide the work up under the headings of various trades, such as "excavator," "bricklayer," and so forth, the general description of materials preceding the detailed enumeration of particular items under the heading of the appropriate trade. This method, however, is usually applied only to specifications for building works.

Some engineers and architects advocate the free use of marginal sketches to further elucidate the intention of the written description, but where the specification is printed this method is inapplicable, owing to the extra expense involved in printing, and in any case it is doubtful whether such details would not be better demonstrated on the drawings. A competent specification writer should be able to describe his meaning with sufficient clearness to enable him to dispense with such a superabundance of illustrations. In the case of any very complicated piece of work, a detail drawing to scale is obviously of more utility than a mere sketch, and in simpler cases a written description should be all that is required.

Trade catalogues form one of the most useful items in the specification writer's stock-in-trade, and here, again, the advantage of system will be apparent. A complete set of trade catalogues filed on the decimal system, and accompanied by a card index in two divisions, one of subjects and the other of names of firms, will enable the engineer to turn up at the shortest notice the information with regard to any manufactured article that he may require, and to make a comparison between the manufactures of different firms, with a view to finding the particular article best suited to his purpose.

In this connection it may be said that the practice of specifying that certain articles shall be supplied by a particular firm is one that should not be carried to excess. It is not an unheard of thing for a manufacturer, who has been specified to supply certain goods, to raise his prices for the occasion, but if estimates are obtained from firms of equal standing and reputation, it is generally possible to obtain a lower price than if the other course were adopted. The selection of one firm to the exclusion of all others may aso suggest unfairness on the part of the engineer, and may create the idea that his selection is not without profit to himself, although it is to the credit of the profession and the manufacturers that cases of bribery are so extremely rare as to be practically non-existent. It may here be remarked that a good commercial knowledge (including the ability to price out roughly the present market value of any ordinary materials and labor) is a distinct advantage to a specification writer, enabling him when selecting goods to thread his way through the maze of trade discounts, discounts for cash, and special discounts for large quantities with which some merchants conceal the actual cash price of their manufactures, especially as in some cases it is not unlikely that he may be called upon for advice upon particular items when the settlement of accounts takes place.

A matter which too seldom receives thorough consideration is the question of what part (if any) of the materials for the works can be obtained locally. The practice of specifying goods which must necessarily be conveyed long distances before they can be utilized, while equally satisfactory materials can be procured near the site of the works, argues negligence on the part of those responsible for drafting the specification, and is usually due to culpable ignorance of local conditions. As illustrating this point, a case may be mentioned where a contract was secured at abnormally low prices, the contractor making a good profit by utilizing the sand and gravel obtained from the excavations, which other less wideawake contractors had counted upon having to bring several miles by road. In this instance it was even hinted that the contractor went to the extent of carting away alleged "surplus material" from the site, which he afterwards turned to his own use and profit.

Although the preparation of bills of quantities does not form part of the work of writing a specification, it may not be out of place to mention that attempts have been made in the past to combine the two documents in one, but as each has an independent function, any attempted combination must be unsatisfactory. The bills of quantities are merely schedules of labor and materials, arranged so that prices may be conveniently attached, and the endeavor to make them serve another purpose is inevitably foredoomed to failure. Moreover, if the quantities are made a part of or annexed to the contract, and any dispute should rise, the court may hold that the contract on the builder's part was not to complete the works, but only to execute the quantities.

It is not possible, within the limits of this paper, to touch upon all the points which may arise in connection with preparing a specification, yet enough has been said to demonstrate that specification writing is worthy to rank high among other more showy, but scarcely more interesting, professional work; indeed, it requires for its satisfactory accomplishment a high degree of technical knowledge, besides something more than a smattering of legal information and (what engineers too often lack a sound commercial training). If, in addition to these qualifications, the specification writer possesses plenty of sound common sense, allied to practical experience in his work, he will be well fitted to assist in dispelling the much too popular fallacy that the preparation of specifications for engineering works is a necessary but uninteresting piece of drudgery, carrying with it no reward but that which always accompanies work well done.

The 10,000,000 lb. Hydraulic Compression Testing Machine, for the Structural Materials Testing Laboratories of the United States Geological Survey.

BY RICHARD L. HUMPHREY, M. AM. SOC. C. E.

There is being constructed for the Structural Materials Testing Laboratories, United States Geological Survey, by Tinius Olsen & Co., Philadelphia, Pa., a vertical compression testing machine of 10,000,000 lbs. capacity. This machine, having a gross weight of over 200 tons and an extreme height above foundation of about 80 ft., is the largest ever constructed.

The machine was primarily acquired for the purpose of testing large blocks of stone made necessary by the study of the building stones of the country, as requested by the supervising architect. Inasmuch as it was deemed desirable to study the effect of flaws and defects of the various kinds in large blocks of natural stone, a machine of this capacity was determined upon. In order to care for a further request of the supervising architect, for data relative to the strength of structural columns of brick and concrete, as well as of structural steel, the original clearance between heads was increased from 25 to 65 ft. Already the need for this machine in the investigation of built-up structures is established through the urgent requests for its early completion.

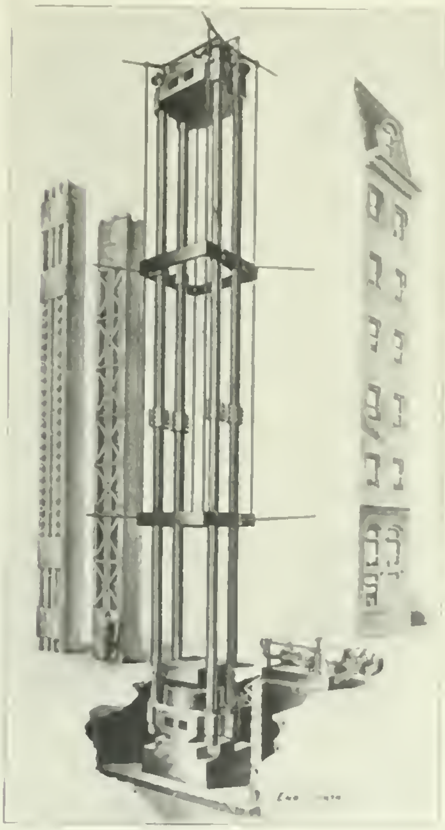
Some idea of its size may be obtained from the accompanying illustration in which has been sketched one of the chords of the Quebec bridge, which collapsed, and also a large chord which was used in the Blackwell's Island bridge. It is readily apparent that this machine is capable of testing built-up structures of even greater size than those referred to.

The following brief description has been prepared because of the interest which has been manifested, and in response to the frequent requests which have been made for information concerning the machine.

The machine is a large hydraulic press, with one adjustable head, and a weighing system for recording the loads developed in it by means of the triple plunger pump. It has a maximum clearance between heads of 65 ft.; the clearance between the screws is a trifle over 6 ft., and the heads are 6 ft. square.

The machine consists of a base containing the main cylinder with a sectional area of 2,000 sq. ins., upon which rests the lower platform or head which is provided with a ball and socket bearing. The upper head is adjustable over four vertical screws (13½ ins. in diameter and 72 ft. 2 ins. long), by means of gearing operating four nuts with ball bearings upon which the head rests. The shafting operating this mechanism is connected with a variable speed motor which operates the triple plunger pump which supplies the pressure to the main cylinder.

The weighing device consists of a set of standard "Olsen" levers upon which is weighed 1/80 of the total load on the main cylinder. This reduction is effected through the medium of a piston and diaphragm. The main cylinder has a diameter of 50 ins., and the smaller a diameter of 5 9/16 ins. The weighing beam is balanced by an automatically operated poise weight and is provided with a device for applying successive counterweights of 1,000,000 lbs. each. Each division on the dial is equivalent to 100-lb. loads, the smaller sub-divisions are possible by means of an additional needle beam.



A 10,000,000 lb. Hydraulic Compression Testing Machine.

The power is applied by means of a 15 H. P., 220-volt variable speed motor operating a triple plunger pump. The gearing operating the upper head is driven by the same motor.

The extreme length of the main screws necessitates splicing, which is accomplished as follows:

In the center of the screws at the splice is a 3 in. threaded pin for the purpose of centering the upper and lower screws; this splice is strengthened by means of split sleeve nuts, which facilitates the removal of the sleeve nuts whenever it is necessary to lower the upper head; after the head has passed the splice the sleeve nuts are replaced.

In order to maintain a constant load a needle valve has been provided which will allow, when the pump is operated at its lowest speed, a sufficient quantity of the oil to flow into the main cylinder to equalize whatever leakage there may be. The main cylinder has a vertical movement of 24 ins.

The speed of the machine for purpose of adjustment, using the gearing attached to the upper head, is 10 ins. per minute. The speed for applying loads, controlled by the variable speed motor driving the pump, varies from the minimum of at least 1/60 in. per minute, to a maximum of at least ½ in. per minute.

The contract provides that the machine shall have an accuracy of at least 1/3 of 1 per cent, for any load over 100,000 lbs. up to the capacity of the machine.

Some idea of the size of the machine may be obtained from a statement of the weight of its principal parts. The castings for the base and the top head weigh approximately 50,000 lbs. each. Each main screw will weigh over 10,000 lbs. The lower platform weighing about 25,000 lbs., and the main cylinder 16,000 lbs. The top of the machine will be about 70 ft. above the top of the floor, and the concrete foundation upon which the machine rests will be about 8 ft. below the floor line.

Administration Bill for the Proposed Waterway from Lockport to Utica, Illinois.

At the last general election the people of Illinois voted in favor of constructing a 14-ft. waterway from Lockport, Ill., the end of the present Chicago Drainage Canal, to the Illinois River near Utica, Ill. The character of the proposed waterway, as outlined by the Internal Improvement Commission, was described in our issue of Oct. 14, 1908. The first step toward carrying out this project is legislative provision for the administration and financing of the work. A bill to this end, which is understood to embody the ideas of the Internal Improvement Commission and is, therefore, known as the administration bill, has been introduced into the Illinois Legislature. The outline of the plan embodied in this measure is as follows:

A board of five commissioners is to be appointed by the governor, the first board to hold office until July 1, 1915. Their successors also shall be appointed by the governor and their terms shall be six years.

The board may adopt an official seal. All deeds and contracts shall be made in the name of the board of commissioners of the Illinois deep waterway, but the board shall not be considered a distinct corporation.

Each commissioner is required to make oath or affirmation faithfully to discharge his duties and to give bond of $25,000.

The commissioners are to receive $5,000 a year salary, while the chairman is to get an additional $2,000, making his salary $7,-

000 as long as he is chairman. The board's attorney shall receive $6,000 a year.

The route for the waterway or canal shall be through and along the sanitary district channel, from the power plant at Lockport to Joliet, thence in, along, or near the Desplaines river to Utica. The waterway shall have a depth throughout its course of not less than 14 ft. and a bottom width of not less than 200 ft., and shall be equipped with locks and dams so as to make it a navigable channel throughout its entire length.

Regarding the expenditures for the work Section 6 says:

"The said board before entering into any contract for the construction of any part of the said deep waterway or canal or any part of the said public works connected therewith shall cause to be made plans and specifications for the said public works, together with reliable and carefully prepared estimates of the cost of constructing, completing and installing all of said public works, which plans and estimates shall show to the satisfaction of said board that the total cost of the construction, completion and installation of said public works can, with certainty, be accomplished, with the proceeds of the $20,000,000 of state bonds authorized to be issued by the amendment to the constitution of the state of Illinois adopted by the vote of the people in the year 1908, and no changes shall thereafter be made in the said plans and specifications which in the opinion of the said board would have the effect of increasing the aggregate cost of said public works to an amount in excess of $20,000,000."

The letting of contracts is covered in Section 8 of the bill as follows:

"All contracts for work to be done by said board under the authority of this act, the expense of which will exceed $500, shall be let to the lowest responsible bidder therefor upon not less than thirty days' public notice, the terms and conditions upon which such contracts are to be let to be given by publication in a newspaper of general circulation in the state of Illinois, and also in an engineering paper having general circulation in the United States. And said board shall have power and authority to reject any and all bids and readvertise; provided, however, said board may cause any piece of work to be performed by the direct employment of labor, without the letting of a contract, which in the discretion of the board, evidenced by the affirmative vote of not less than four of the commissioners, can be most economically performed by that method."

Section 12 provides that on Jan. 1 of each year the board shall make a full report to the governor of all expenditures in the 12 months up to Nov. 30 preceding.

Section 13 gives the board authority to lease water power on the following conditions:

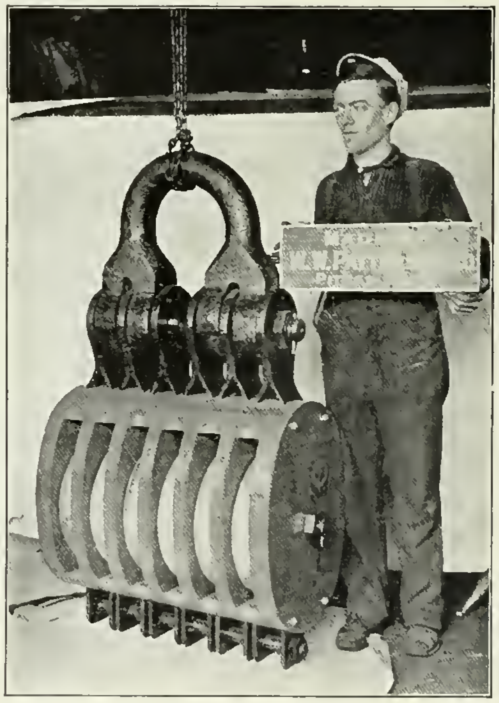
"No lease shall be made of any water power until the machinery and appliances for making the same available shall have been constructed and substantially completed. Before any such lease shall be made at least 30 days' public notice of the intended letting shall be given by publication in a newspaper published in the city of Springfield and also in the city of Chicago and such other notice as the board shall deem best. . . . No lease shall be for a period exceeding 10 years, but the said board may provide for the extension of any lease from time to time not exceeding 10 years at any one time at a rent to be fixed by an appraisal to be made by three distinguished appraisers, to be selected or appointed in such manner as shall be provided in the lease."

Under section 14 all rents and other moneys received by the board shall be deposited in the state treasury as a separate fund.

The indications are that many amendments will be offered to this bill. Probably the most strenuous fight will be made by the advocates of an alternative scheme worked out by Mr. Lyman E. Cooley. Mr. Cooley's plan provides for a 24-ft. channel and a different system of operation and administration.

Six-Sheave Wooden Blocks for the Havre de Grace Bridge Erection Plant.

The accompanying view shows one of eight large wooden blocks being used in the erection of the steel work for the Baltimore & Ohio R. R. bridge at Havre de Grace, Md. Each block weighs 1,350 lbs., measures 30 ins. across the shell and has a rated capacity of 60 tons.



Six-Sheave Wooden Block.

The shackle is a solid forging 3½ ins. in diameter; the eyes measure 8 ins. across, and each of the four legs is 3 ins. wide. The head bolt is 3 ins. in diameter. The straps are all 1½x½-ins. and welded at the head, where they are swelled to a diameter of 8 ins. across the eye, corresponding to the diameter of the lugs of the shackle. The straps extend through the shell and a 1½-in. stiffener bolt goes through them at the bottom. The galvanized and metalined-bushed sheaves are 15½x2¾-ins. and run on a 2-in. pin On each cheek there are three 3/16-in. plates to prevent splitting and the shell is held together by four sets of cross rivets.

These blocks were built by the W. W. Patterson Co., of Pittsburg, Pa.

The 25th annual meeting of the Connecticut Society of Civil Engineers will be held Feb. 9 and 10 at Pythian Hall, 11 Central Row, Hartford, Conn. The program includes the following papers: "Reinforced Concrete Sewer at New Haven," by Henry J. Kellogg, New Haven; "Tunnel and Concrete Sewer at Hartford," by Roscoe N. Clark, Hartford; "Some Observations on the Life of Steel Bridges," by Herbert C. Keith, New York City; "The Engineer In Court," by Edward W. Bush, Hartford; "Reinforced Concrete Locomotive House at Waterbury," by G. M. Poley, Waterbury; "Costs of Sewer Work," by J. Frederick Jackson, New Haven; "An Efficient Indexing System," by Wm. Gavin Taylor, Waterbury.

During 1908 20 civil service examinations were held for positions under the New York State Engineer. The total number of appointments was 480.

Engineering-Contracting Monthly Review Index of Civil Engineering Literature.

A classified index and review of the civil engineering papers, articles, reports, pamphlets and books published during the month just passed is given in the succeeding pages. The literature indexed and reviewed—with the exception of books—relates solely to civil engineering. In the section devoted to Book Reviews all books in all branches of engineering are listed as received and such of them as seem worthy are reviewed as fully as due regard for conciseness will permit. In choosing books for review rigid selection is exercised. Next to careful choice of books for review timeliness of review is sought. All books are reviewed within a month of their receipt. The same statement is true of the articles and papers that are indexed. Also, as in choosing books for review, the choice of articles and papers for indexing is based on merit. Numerical strength in "titles indexed" is not sought; excellence of selection is sought.

The purpose of the Monthly Review Index is to inform civil engineers and contractors of the articles and papers of merit that are published each month, in such a way as will give a clear idea of their character and scope, and to supply the reader with the date and place of publication, the length of each article and the cost at which it can be procured. The name, adopted abbreviation, place of publication and price per number of each periodical examined for civil engineering articles are given in the list immediately following. The other information is given in the index proper for each article separately.

Books reviewed will be sent post paid on receipt of price by the Book Department of Engineering-Contracting; periodicals, etc., containing articles indexed should be ordered direct from the publishers.

LIST OF PERIODICALS INDEXED.

American Architect (Am. Arch.), New York, N. Y.; w; 7x10 in.; 15 cts.
American Builders' Review (Am. Bldrs. Rev.), San Francisco, Cal.; m; 7x10 in.; 50 cts.
American Carpenter and Builder (Am. Car. & Bldr.), Chicago, Ill., New York, N. Y.; m; 7x10 in., 20 cts.
American Engineer and R. R. Journal (Am. Engr. & R. R. Jl.), York, N. Y.; m; 7x10 in.; 20 cts.
American Gas Light Journal (Am. G. L. Jl.), New York; N. Y.; w, 10x13 in.; 10 cts.
American Institute of Electrical Engineers Proceedings (Am. I. of E. E. Proc.), New York, N. Y.; m; 4x7 in., 50 cts.
American Machinist (Am. Mchst.), New York; w; 7x10 in.; 15 cts.
American Society of Civil Engineers Proceedings (Am. Soc. C. E. Proc.), New York, N. Y.; m; 4x7 in.; 75 cts.
American Society of Mechanical Engineers Proceedings (Am. Soc. M. E. Proc.), New York, N. Y.; m; 4x7 in.; 50 cts.
Annales des Ponts et Chaussees (An. P. & C.), Paris, France, m.
Applied Science, Toronto, Ont.; m; 6x9 in.; 20 cts.
Architects and Builders Journal (Arch. & Bldrs. Jl.), Baltimore, Md.; m; 9x12 in.; 20 cts.
Architects and Builders Magazine (Arch. & Bldrs. Mag.), New York, N. Y.; m; 5x8 in.; 20 cts.
Architect and Engineer of California (Arch. & Engr.), San Francisco, Cal.; m; 5x7 in.; 15 cts.
Cassier's Magazine (Cas. Mag.), New York; m; 5x8 in.; 25 cts.
International Railway Congress Bulletin (Int. Ry. Cong. Bul.), Brussels; m; 50 cts.
California Journal of Technology (Cal. Jl. of Tech.), Berkeley, Cal.; m; 4x7 in.; 25 cts.
Canadian Architect (Can. Arch.), Toronto, Ont.; m; 7x10 in., 20 cts.
Canadian Cement and Concrete Review (Can. Cem. & Conc. Rev.), Toronto, Ont.
Canadian Engineer (Can. Engr.), Toronto, Ont.; w, 7x11 in.; 10 cts.
Canadian Machinery and Manufacturing News (Can. Mach. & Mfg. News), Toronto, Ont.; m; 7x10 in.; 15 cts.
Canadian Mining Journal (Can. Min. Jl.), Toronto, Ont.; bi-w; 7x10 in., 20 cts.
Canadian Municipal Journal (Can. Mun. Jl.), Montreal, Que.; m; 6¾x10 in.; 10 cts.
Canadian Society of Civil Engineers Proceedings (Can. Soc. C. E. Proc.), Montreal; m; 4x7 in.; 50 cts.
Carpentry and Building (Carp. & Bldg.), New York, N. Y.; m; 11x8 in., 10 cts.
Cassier's Magazine (Cas. Mag.), New York, m; 5x8 in.; 25 cts.
Cement, New York, N. Y.; bi-m, 5x8 in.; 25 cts.
Cement Age (Cem. Age), New York, N. Y.; m; 4x7 in.; 10 cts.
Cement and Engineering News (Cem. & Eng. News), Chicago, Ill.; 7x10 in.; 25 cts.
Cement Era (Cem. Era), Chicago, Ill.; m, 7x10 in., 10 cts.
Cement World (Cem. Wld.), Chicago, Ill.; m; 9x11 in.; 10 cts.
Chemical Engineer (Chem. Engr.), Chicago, Ill.; m; 4x7 in.; 15 cts.
Clay Worker (Cl. Wkr.), Indianapolis, Ind.; m; 7x10 in.; 20 cts.
Compressed Air (Comp. Air), New York, N. Y., m; 5x7 in.; 10 cts.
Concrete, Detroit, Mich.; m; 6x9 in.; 15 cts.
Concrete Age (Conc. Age), Atlanta, Ga.; m, 9x11 in.; 10 cts.
Concrete and Constructional Engineering (Conc. & Cons. Eng.), London, England; m; 5x7 in.; 25 cts.
Concrete Engineering (Conc. Eng.), Cleveland, O., m, 7x10 in.; 10 cts.
Contractor (Contr.), Chicago, Ill.; bi-w; 7x10 in.; 20 cts.
Cornell Civil Engineer (Cor. Civ. Engr.), Ithaca, N. Y.; m; 4x7 in.; 25 cts.
Domestic Engineering (Dom. Engr.), Chicago, Ill.; w, 6x9 in.; 10 cts.
Earth and Rock, Chicago, Ill.; bi-w, 7x10 in.; 10 cts.
Electrical Age (Elec. Age), New York, N. Y.; m; 7x10 in.; 10 cts.
Electrical Review (Elec. Rev.), New York, N. Y.; 8x10 in.; 10 cts.
Electric Railway Journal (Elec. Ry. Jl.), New York, N. Y.; w, 7x10 in.; 10 cts.
Electrical World (Elec. Wld.), New York, N. Y.; w, 7x10 in.; 10 cts.
Electric Traction Weekly (Elec. Trac. Wkly.), Chicago, Ill.; w, 7x10 in.; 10 cts.
Engineer (Engr. Lon.), London, England; w, 4x11 in.
Engineer (Engr.), Chicago, Ill.; bi-w; 7x10 in.; 20 cts.
Engineer (Eng.), London, England; w; 8x11 in.
Engineers' Club of Philadelphia Proceedings (Engr's Club Phila. Proc.), Philadelphia; qr; 4x7 in.; 25 cts.
Engineering-Contracting (Eng.-Contr.), Chicago, w, 7x10 in.; 10 cts.
Engineering Digest (Eng. Dig.), New York, m, 5x8 in.; 20 cts.
Engineering and Mining Journal (Eng. & Min. Jl.), New York; w, 7x10 in.; 15 cts.
Engineering Magazine (Eng. Mag.), New York; [illegible]; 25 cts.
Engineering News (Eng. News), New York; w, 8x11 in.; [illegible]
Engineering Record (Eng. Rec.), New York; w, 8x11 in.; [illegible]
Fire and Water Engineering (F. & W. Eng.), New York, N. Y.; 8x11 in.; 10 cts.
Le Genie Civil, Paris, France; w.
Good Roads Magazine (Gd. Rds. Mag.), New York, N. Y.; m; 7x10 in.; 10 cts.
Industrial Magazine (Ind. Mag.), Cleveland, O.; m, 4x7 in.; 15 cts.
Industrial World (Ind. Wld.), Pittsburg, Pa.; w, 7x10 in.; 10 cts.
Inland Architect (In. Arch.), Chicago, Ill.; m; 7x11 in.; $1.
Insurance Engineering (Ins. Eng.), New York; m; 4x6 in.; 25 cts.
Iron Age, New York, N. Y.; w, 7x11 in.; 15 cts.
Iron Trade Review (Iron T. Rev.), Cleveland, O.; w; 7x10 in.; 15 cts.
Irrigation Age (Irr. Age), Chicago, Ill.; m; 7x9 in.; 10 cts.
Journal Association of Engineering Societies (Jl. Assn. Engr. Soc.), Boston, Mass.; m; 4x7 in.; [illegible] cts.
Journal Franklin Institute (Jl. Frank. Inst.), Philadelphia, Pa.; m; 4x7 in., 50 cts.
Journal New England Waterworks Association (Jl. N. E. W. W. Assoc.), Boston, Mass.; q; 4x7 in.
Journal Western Society of Engineers (Jl. W. Soc. Engrs.), Chicago, Ill.; bi-m, 4x7 in.; 50 cts.
Journal of Electricity, Power and Gas (Jl. Elec. P. & G.), San Francisco, Cal.; w, 7x10 in.; 10 cts.
Journal of Worcester Polytechnic Institute (Jl. W. P. I.); m; 4x7 in.; 20 cts.
Machinery, New York, N. Y.; m; 7x11 in.; 20 cts.
Marine Review (Marine Rev.), Cleveland, O.; w, 7x10 in.; 15 cts.
Mines and Minerals (Mi. & Ms.), Scranton, Pa.; w, [illegible]; 2[illegible] cts.
Mining and Scientific Press (Min. & Sci. Pr.), San Francisco, Cal.; w; 7x11 in.; 15 cts.
Mining Reporter (Min. Rep.), Denver, Colo.; w, 7x10 in.; 15 cts.
Mining World (Min. Wld.), Chicago, Ill.; w, 7x10 in.; 10 cts.
Modern Machinery (Mod. Mchy.), Chicago, Ill.; m; 7x10 in.; [illegible] cts.
Municipal Journal and Engineer (Mun. Jl. & Eng.), New York, N. Y.; w, 7x10 in.; 10 cts.
Municipal Engineering Magazine (Mun. Eng. Mag.), Indianapolis, Ind.; m; 4x7 in.; 25 cts.
Ores and Metals (O. & M.), Denver, Colo.; bi-w; [illegible] cts.
Pacific Building Engineer (Pac. Bldg. Engr.), Seattle, Wash.; w, 9x11 in.; 15 cts.
Popular Mechanics (Pop. Mech.), Chicago, Ill.; m; [illegible]; 10 cts.
The Polytechnic (Poly.), Troy, N. Y.; m; [illegible]; 15 cts.
Power and Engineer (Pwr. & Engr.), New York; [illegible]; 10 cts.
Railway Age Gazette (R. R. Age Gaz.), New York; w; 8x11 in.; 15 cts.
Railway Master Mechanic (Ry. M. M.), Chicago; m; [illegible]; 10 cts.
Railway and Engineering Review (Ry. & Eng. Rev.), Chicago, Ill.; w, 9x11 in.; 10 cts.
Railway and Locomotive Engineering (Ry. & Loco. Eng.), New York, N. Y.; m; [illegible] in.; 20 cts.
Railway and Marine World (R. & M. Wld.), Toronto, Ont.; m; [illegible]
Railway Engineering and Maintenance of Way (Ry. Eng. & M. W.), Chicago, Ill.; m, 7x10 in.; 10 cts.
Roadmaster and Foreman (Rd. & For.), Chicago; [illegible] cts.
Rock Products (Rk. Prod.), Chicago, Ill.; [illegible]; 10 cts.
Rose Technic, Terre Haute, Ind.; m; 4x[illegible] in.; [illegible]
School of Mines Quarterly (Sch. Min. Quart.), New York, N. Y.; qr; 4x7 in.; [illegible]
Schweizerische Bauzeitung, Zurich; w.
Scientific American (Sci. Am.), New York; w; 8x11 in.; [illegible]
Scientific American Supplement (Sci. Am. Sup.), New York, N. Y.; w; 9x11 in.; 10 cts.
Sibley Journal of Engineering (Sib. Jl. Eng.), Ithaca, N. Y.; m; 4x7 in.; [illegible]
Stevens Institute Indicator (Stev. Inst. Ind.), Hoboken, N. J.; m; [illegible]
Street Railway Bulletin (St. Ry. Bul.), Boston; m; [illegible] cts.
Surveyor (Surveyor), London, England; w, 6x11 in.; [illegible]
Technology Quarterly (Tech. Qr.), Boston; qr; 4x6 in.; [illegible]
U. S. Department of Agriculture Bulletin (Dept. Agr. Bul.), Washington, D. C.; 4x7 in.
U. S. Geological Survey Bulletin (Geo. Surv. Bul.), Washington, D. C.; 4x7 in.
Waterproofing and Fireproofing (W. P. & F. P.), Detroit, Mich.; m, 7x10 in.; 10 cts.
Zeitschrift d. Oest. Ing. u. Arch. Ver., Vienna; w.
Zeitschrift d. Ver. Deutscher Ing., Berlin, w.

ROADS AND STREETS.

Modern Road Management.—By E. Purnell Hooley. Gd. Rds. Mag., January, 1909; 1½ pp.

A paper presented at the First International Road Congress. It discusses the maintenance of roads in view of the increasing use of motor vehicles.

Trunk Line Highways in New England.—Gd. Rds. Mag., January, 1909; 6 pp.

A discussion of highways and their uses, by Harold Parker, chairman of the Massachusetts Highway Commission and James H. MacDonald, State Highway Commissioner of Connecticut.

Small Cubes for Road Paving.—Mun. Jl. & Eng., Jan. 6, 1909; ½ p.

A suggestion for improving macadam roads by placing 2-in. cubes of stone or artificial material.

Examination of Road Tars.—Mun. Jl. & Eng., Jan. 6, 1909; 1½ pp.

Describes some English methods of testing tars to be used for road purposes. Describes the kinds of tars used, their desirable characteristics, and various tests.

Asphalt Testing—Penetration.—By Harry Tipper. Mun. Jl. & Eng., Jan. 6, 1909; 2½ pp.

Describes a number of complications of this test and recommends a limit of variation in penetration at different temperatures.

Systems of Highway Administration Compared.—By W. Rees Jeffreys. Surveyor, Dec. 25, 1909.

This is a conclusion of a comparative examination of the highway systems of France, England, Wales, Scotland, Spain, Holland and other countries. The article includes a summary in tabular form of the systems of highway administration in the various countries.

The Construction of Sand-Clay Roads.—By W. L. Spoon. Eng.-Contr., Jan. 27, 1909; 1 p.

General article describing construction of sand clay roads.

The Work of the Municipal Asphalt Repair Plant of Indianapolis, Ind.—Eng.-Contr., Nov. 27, 1909; ⅔ p.

Gives some general cost figures on asphalt repair work at Indianapolis in 1908.

Notes on Highway Improvements.—By D. McD. Campbell. Can. Eng., Jan. 8, 1909; 3½ pp.

A paper devoted to location and grades of wagon roads and especially the drainage of roads, considering surface drainage, side ditches and subsoil drainage.

Report on the Recent First International Road Congress.—By N. P. Lewis. Eng. News, Jan. 21, 1909; 4¼ pp.

Abstract of a report made to the Board of Estimates and Apportionment of New York city by its chief engineer, Mr. Lewis. Summarizes the information presented in the papers and discussions before the Congress.

Removing Snow from Streets with a Road Grader, and Some Costs.—Eng.-Contr., Jan. 6, 1909; ⅔ p.

Describes method employed in New York City of removing snow from the streets, a road grader being used for the work.

Examination of Tars for Use on Roads.—Eng.-Contr., Jan. 13, 1909; 2⅔.

Describes some English methods for the examination of tars to be used on roads.

Standard Specifications for Portland Cement Roads and Portland Cement Sidewalks.—Eng. Contr., Jan. 20, 1909; 1⅔ pp.

The specifications were prepared by a special committee of the National Association of Cement Users, and were submitted at the recent annual convention of that association.

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Standard Details for Highway Construction.—Eng.-Contr. Jan. 6, 1909; 1½ pp.

Illustrates and describes some of the standards of the Massachusetts Highway Commission for drains, catch basins, fences, etc.

The Mineral Rubber Pavements of the South Park System, Chicago. Eng. Rec. Jan. 30, 1909; 1⅓ pp.

A description is given of this new pavement and the method used in laying it in the parks of Chicago.

SEWERS.

The Construction of the Bronx Valley Sewer.—Eng. Rec. Jan. 9, 1909; 3 1-3 pp.

A description of the trunk sewer is given as well as the methods used in constructing it, together with the tools and appliances used.

Asphalt Sewer Pipe Joints at Monmouth, Illinois.—By John S. Bates. Eng. Rec., Jan. 9, 1909; 1 p.

Describes the laying of two pipe sewers for which asphalt was used to make the joints water tight. The author believes such a joint is made better than the ordinary cement joint.

Cost of a 66-Inch Brick Sewer at Gary, Indiana.—By E. M. Schetlow. Eng. Rec. Jan. 2, 1908; 1 p.

The cost of the work in detail is given listed under different heads, as excavation, pumping, hauling materials, sheeting, laying sewer materials, back filling, general expense and total cost.

Sewage Purification vs. Water Filtration.—By George C. Whipple. Mun. Jl. & Eng., Jan. 6, 1909; 3½ pp.

A paper read before the American Society of Municipal Improvements.

Concrete Viaduct for a Sewer.—By W. R. Worthington. Can. Eng., Jan. 29, 1909; 1½ pp.

An account is given of the construction of a concrete viaduct built for building a sewer. Photographs and plans are shown.

A System of Collecting Cost Data with Particular Reference to a Sewer Contract.—Engr.-Contr., Jan. 13, 1909; 3⅓ pp.

The system of collecting cost data described in this article is that used by a large construction company. Blanks are shown for recording costs. The method of collection is described in detail.

Cost of Constructing a 66-in. Sewer at Gary, Ind.—Eng.-Contr., Jan. 27, 1909; 1¼ pp.

This sewer was constructed through quick sand, which was made dry by sinking well points and pumping. The detailed costs of each part of the construction are given.

WATERWORKS AND HYDRAULICS

A Glance at the Water Supply of Philadelphia. By John C. Trautwine, Jr. N. E. W. W. Assn., Dec. 1908; 22 pp.

A short history of the water supply of this city during the past 100 years, with a description of the present water works, including the filtration plant, is given.

Stream Flow Data.—By Charles E. Chandler. N. E. W. W. Asso., Dec., 1908; 9 pp.

Tables showing the stream flow of the Sudbury River from 1875 to 1898, the South Branch of the Nashua from 1897 to 1906, and the Merrimac River from 1890 to 1906 are given.

The Conservation of Water Resources.—By M. O. Leighton. N. E. W. W. Asso. Dec., 1908; 7 pp.

A plea for the systematic conservation of water resources for water supply, power and navigation and showing engineers that it is their duty to educate the public on this subject in order to obtain the proper legislation.

The New Covered Filters for Yonkers, N. Y.—Eng. Rec., Jan. 16, 1909; 2⅓ pp.

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Goderich Sedimentation Basin.—By J. Grant MacGregor. Can. Engr., Jan. 1, 1909; 3½ pp.

In this article the writer describes the design of the concrete sedimentation basin built by the Canadian town of Goderich to improve their water supply. Illustrated with a number of drawings.

Vancouver's Water Supply.—Can. Engr., Jan. 15, 1909; 2 pp.

A description of the new water supply of this city. Much of the article is given over to the wooden pipe line built to carry the water. Some costs are given.

Wrought Iron Cement Lined Water Pipe.—By Leonard Metcalf. Eng. News, Jan. 7, 1909; 5¾ pp.

This is a very complete record of the experience of New England cities with the making, laying and service of cement lined wrought iron water pipe. The early history, tests, manufacture, carrying capacity, cost and general experience with such pipe are all discussed. There are many cost data. A concluding section summarizes the advantages and disadvantages of cement-lined pipe.

Novel Reinforced Concrete Tower and Tank.—By R. B. Tufts. Eng. News, Jan. 7, 1909; 1⅓ pp.

Describes and shows essential details of tower and tank which is a hollow, chimney-like shaft, 30 ft. inside diameter at the ground and tapering to a truly cylindrical 22 ft. inside diameter at a point 90 ft. above ground, where it supports a 100,000-gallon cylindrical tank with a spherical bottom. The structure is wholly of reinforced concrete; methods of construction, strains, and structural details are stated briefly.

Failure Under Test Load of a Reinforced Concrete Reservoir, Annapolis, Md.—By. R. H. Danforth. Eng. News, Jan. 14, 1909; 1 p.

Reservoir had slab and beam roof carried on columns and a slab floor. Failed under test load by sheering of column footings. Article describes construction and characteristics of the failure.

Cement Lined Water Pipe.—Mun. Jl. & Eng., Jan. 6, 1909; 3½ pp.

From a paper by Leonard Metcalf, read before the New England Water Works Association. It describes briefly the types of construction and gives statistics relative to its use. The advantages and disadvantages as compared with cast iron pipe are also discussed.

Stovepipe Wells.—Mun. Jl. & Eng., Jan. 13. 1909; 1½ pp.

Describes method employed by the Board of Water Supply of New York City in sinking wells. The well is a double casing of short lengths of pipe forced down by jacks.

Stresses in Masonry Dams.—By William Cain. Am. Soc. C. E. Proc. January, 1909; 15 pp.

A mathematical discussion of the stresses in masonry dams and their effect on the design of such structures.

New Intake Tunnel.—By C. W. Allen. Can. Eng., Jan. 29, 1909.

An account of an intake tunnel built by the city of Toronto in connection with their water works. The methods of doing the work are described and the article is well illustrated with drawings showing many of the details of the work.

New High Service Reservoir of the Baltimore Water System.—Eng. Rec., Jan. 23. 1909; 1 p.

Describes the work being done on this dam and shows a cross section of the embankment or dike that is being built to retain the water.

Cost of Setting Water Meters and Laying Service Pipes.—By W. H. Shillinglaw. Eng.-Contr., Jan. 20, 1909; ⅓ p.

Describes the itemized cost of setting water meters at Brandon, Manitoba, during 1908. The blank form used in recording costs is shown.

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Granite Reef Dam and Gate Mechanism.—By F Teichman. Eng. News, Jan. 7, 1909; 3½ pp.

This article describes in a general way the purpose and construction of the Granite Reef division dam for the Salt River, Arizona, irrigation project. Plans and views of the structure are given and also details of operating mechanism for the sluice gates, and of the sluice and regulator gates.

RIVERS, HARBORS AND CANALS.

New Piers for Trans-Atlantic Steamships, Chelsea Improvement, New York City.—Eng. News Jan. 14, 1909; 7½ pp.

Gives a very full general description of the new large piers and particularly of the steel pier shed construction, with views and typical plans. Contract prices and some erection speed records are given and methods of erection are described The steel and concrete pier shed structural details are of interest.

Recent Improvements to the Harbor at Cleveland, Ohio.—Eng. Rec., Jan. 16, 1909; 1½ pp.

A description of the protection work done in this harbor, which is said to be the greatest undertaking of the kind in the great lakes. A heavy rip-rap breakwater was built.

Permanent Improvements of the Ohio River.—Eng Rec., Jan. 23, 1909; 2½ pp.

This article concludes a series of five articles on this subject in which the engineering and construction work done on this river have been well described and illustrated.

Concrete Pile Dike for River Bank Revetment.—Eng. Rec., Jan. 23, 1909; 1 p.

An account of work done on the Missouri River to rebuild an old dike with concrete piles. A table of the cost of the pile work is given.

RAILWAYS.

Revision of Line of the Kanawha & Michigan Ry.; with Unit Costs of the Work.—By J. A. Stocker. Eng. News, Jan. 7, 1909; 2 pp

Shows map of old and ruined line, section of new 713-ft. tunnel, and details of forms for concrete lining, and gives general description of the methods of construction. Unit costs of various items of the work are stated.

New Rail Specifications of the Pennsylvania R. R. System.—Eng News, Jan. 14, 1909, ¾ p.

Reprints new specification for rails adopted by the Pennsylvania R. R. system.

Carolina, Clinchfield & Ohio Ry.—Eng. News, Jan. 21, 1909; 5¾ pages.

The heavy construction work involved and the high character of line produced makes this railway one of the most notable pieces of railway engineering of recent years. The article describes the structural features of the road, history, location, terminals, bridges, roadbed and track and engineering organization at length. Structural plans of bridges are shown and maps of special pieces of difficult locations.

Elements of a Successful Railroad Official.—By W J Harahan. Can. Engr, Jan. 1, 1909, 1 pp.

This is a paper by the president of the Erie R. R., delivered before the New York Club, and discusses at some length the way a successful railway official handles his men and work

New Bridge Crossing the Mississippi River at Clinton, Ia., Chicago & Northwestern Ry.—By F. H. Bainbridge. Eng. News, Jan. 21, 1909; 6⅓ pp.

Describes interestingly the old bridge built in 1859 and the various repairs and changes made to strengthen it, and gives full details of the large modern steel structure recently built to take its place Views elevations plans and details are given of the new bridge's foundations and steel work. There are notes on design and on methods of construction. The drawings of caisson work are valuable

Shipment of Inflammable Articles and Acids.—By Col. B. W. Dunn Proc. Ry. Club of Pittsburg, December, 1908; 33 pp.

An address delivered before the club showing the need of regulating the shipment of explosives and the results that can be obtained, and calling attention to the reason of adopting certain regulations.

The Construction Between the Westerly Approach and the Subaqueous Section of the Detroit Tunnel.—Eng Rec, Jan 30, 1909; 2½ pp.

An account of the coffer-dam work, in which the connection of the land and river sections of this tunnel was made. Illustrated with drawings and photographs.

Comments on the Manufacture and Use of Steel Rails.—By Franklin E. Abbott. Eng.-Contr., Jan. 6, and 20, 1909; 6 pp.

This is a good general article describing the manufacture of steel rails, beginning with the mining of the ore, and carrying the work through the various processes until the finished rail is ready for delivery.

Methods and Cost of Constructing T-Rail Track with Carnegie Steel Ties, Utica & Mohawk Valley Ry.—Eng.-Contr, Jan. 20, 1909; 1⅓ pp.

Describes in detail the method of construction and gives the itemized cost of the work. Several jobs of work are included in the cost figures.

BRIDGES, BUILDINGS AND FOUNDATIONS.

Rio Conchos Bridge of the Kansas City, Mexico & Orient.—By W. W. Colpitts. Ry. Age. Gaz. Jan. 22, 1909; 5¼ pp.

Description of a bridge built in Mexico by this railroad company. Description in great detail is given of how the piers and foundations were built, also of placing the steel with costs of the work. The article is well illustrated with photos and drawings.

The Strength of Riveted Joints.—By J. W. Rausch. Can. Eng., Jan. 8, 1909; 4 pp.

Considers lap joints, single riveted, double and triple riveted, and butt joints with double and triple riveted. Each class of work is illustrated by an example.

Nickel Steel for Bridges.—By R. E. Chadwick. Can. Eng., Jan. 15, 1909; 2 pp

An article based on the paper delivered by J. A. L. Waddell before the Am. Soc C. E. on nickel steel. A good summary of the use of this metal for bridges.

Surface Drainage of Permanent Bridges.—By Daniel B. Luten. Gd. Rds. Mag, January, 1909; 2 pp.

Describes a number of methods of providing surface drainage for concrete bridges. A number of illustrations are given showing the methods

Connecticut Ave. Bridge, Washington, D. C.—Gd Rds. Mag., January, 1909; 3 pp

Illustrates and describes the construction of the $850,000 concrete bridge at Connecticut Ave., Washington. The bridge consists of five 150-ft arches, separated from each other by piers 20 ft wide

Design of Centering for 233-ft. Concrete Arch, Walnut Lane Bridge, Philadelphia, Pa., with Some Comparisons of Cost.—Eng-Contr, Jan. 6 and 20; 6 pp

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Reinforced Concrete Construction in the Hartford Armory.—Eng. Rec., Jan. 9, 1909; 2⅓ pp.

Describes the design of the building and the work done on it. The construction of the roof was of special interest. Illustrated by drawings and photographs.

Arch for Supporting a Floor of the Christopher Warehouse, Jacksonville.—Eng. Rec., Jan. 16, 1909; 1½ pp.

An account of a warehouse built of concrete, the interesting feature being an arch to support the second floor.

Cost Account of Seine River Bridge, St. Boniface.—Can. Engr., Jan. 15, 1909; 2 pp.

This bridge was located in Manitoba. Description of the structure is given and total cost of each item of the work.

Reinforced Concrete Water Tower for the Atlantic Compress Co., Atlanta.—By R. B. Tufts. Eng. Rec., Jan. 2, 1909; 1 p.

A description is given of this reinforced concrete water tower, both of its design and also construction. The tank holds 100,000 gals., and is supported 100 ft. above the ground.

Concrete Aggregates.—Surveyor, Jan. 8, 1909; 2 pp.

Report of a special commission of the British Fire-Prevention Committee appointed to report upon and define the aggregates suitable for concrete floors intended to be fire resisting.

St. George Reinforced Concrete Retaining Wall.—Mun. Jl. & Eng., Jan. 13, 1909; 4½ pp.

Describes the construction of the large retaining wall along South St. and Jay St., at St. George, New York City. The wall is of reinforced concrete, having an L-shaped cross section.

Methods and Costs of Rock Excavation and Washing Gravel for a Concrete Dam.—By Wm. C. Steele, Engr.-Contr., Jan. 6, 1909; 1 p.

Gives the cost in detail of rock excavation, showing wages paid, also the detail cost of washing gravel for concrete. The work was done in Wyoming.

Using a "Skullcracker" and Lifting Magnet for Breaking up a Concrete and Masonry Foundation.—Eng.-Contr., Jan. 6, 1909; ⅓ p.

Describes the method followed in breaking up a heavy concrete and masonry foundation by dropping a 10-ton iron ball from a height. The ball was lifted and let drop by means of a lifting magnet.

Cost of Concrete Construction as Applied to Buildings.—Eng.-Contr., Jan. 13, 1909; 5 pp.

Describes the method of a prominent concrete engineering firm for collecting cost data of concrete work, giving samples of the record blanks used. Costs are also given for form work, and concrete for columns, floors, walls and foundations. These costs are average costs for from 10 to 20 structures in each case. The test analyzes the cost table and gives various suggestions regarding the use of such cost figures in making estimates.

Cost of a Concrete Culvert.—Eng.-Contr., Jan. 13, 1909; ⅓ p.

Gives the detailed cost figures of constructing a 3x3-ft. culvert, containing 148 cu. yds. of concrete.

Cost of Reinforced Concrete Siphon for the Belle Fourche Irrigation Works.—Eng.-Contr., Jan. 20, 1909; 1⅔ pp.

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Tests of Strength of Concrete Joints.—Eng.-Contr., Jan. 20, 1909, 1½ pp.

Beams were made with different kinds of joints and tested by flexure in comparison with beams having no joints. The method of making the test and the test results are given in detail. The tests showed the scarf joint to be the strongest. This is an article of unusual interest to concrete engineers.

Method of Underpinning a Building Wall with a 55-ft. Span Reinforced Concrete Girder.—Eng.-Contr., Jan. 27, 1909, 2 pp.

Describes the conditions necessitating the underpinning of a building and the reasons for selecting a large concrete girder for the purpose. Detailed drawings of the girder and its foundations are given and the design and method of construction are described.

Value and Cost of Steam Curing of Concrete Blocks.—By F. S. Phipps. Eng.-Contr., Jan. 17, 1909, ¾ p.

Gives interesting details of the method of steam curing concrete blocks and states in some detail the cost of such work.

Methods and Cost of Constructing a Concrete Sewer in Freezing Weather.—Eng.-Contr. Jan. 27, 1909; 1½ pp.

This is an unusually valuable article describing the methods and costs of constructing a 30-in. sewer, 1,360 ft. long, during November and December, 1908, with the thermometer averaging 15 degrees above zero. The sewer was constructed with a metal form and special methods were employed to prevent injury to the concrete by freezing. The details of construction are given fully and the cost of the work including itemized account of frost preventives are given.

Method of Finishing Concrete Surfaces by Scrubbing, Followed by an Acid Wash, with an Estimate of Cost.—Eng.-Contr., Jan. 6, 1909; 2¼ pp.

This article shows six handsome half-tone views of concrete surfaces of various kinds, which were produced by first washing green concrete with water, then etching the washed surfaces with acid. A description of this material of finishing is given and some estimates of the cost of the work are furnished.

Concrete Blocks for Tunnel Lining and Retaining Wall Protection.—Eng. Rec., Jan. 30, 1909, ⅓ p.

Tells of the use of concrete blocks for tunnel lining and retaining walls on the Mexican Central Ry.

Bonding of New to Old Concrete.—By E. P. Goodrich. Am. Soc. C. E. Proc. January, 1909; 13 pp.

First takes up the literature of the subject, showing the need of having a perfect bond. Then considers patented processes of making such a bond. Then gives several pages to published tests, and ends the article by giving an account of the author's own experiments on this subject.

Action of Frost on Cement and Cement Mortar, Together with Other Experiments on These Materials.—By Ernest R. Matthews and James Watson. Am. Soc. C. E. Proc. January, 1909; 14 pp.

An account of experiments made to show the effect of frost and alternate frost and thaw on the tensile strength of cement and cement mortar, the temperature below which it is detrimental to mix Portland cement concrete, the absorption of water by dry cement, and the quantity of water required to be added to cement to produce complete hardening. The results obtained are given.

EARTH AND ROCK EXCAVATION.

The Equipment of an Electric Power Shovel, Together with Some Cost Records.—Engr.-Contr., Jan. 6, 1909; 1 p.

Shows how certain objectionable features of operating a power shovel with electricity is overcome, and gives the cost of operating such a shovel.

Record of Drilling Test Holes by Hand and Some Costs.—Engr.-Contr., Jan. 6, 1909, ½ p.

The detail record of operating a hand power drill for seven days is given showing the amount of holes drilled and the cost of the work.

Drilling Blast Holes with a Hydraulic Giant and the Cost of a Hydraulic Fill Dam.—Engr.-Contr. Jan. 13, 1909, ½ p.

Gives an account of a dam built in California. The yardage moved with the amount of water pumped is shown and the detail cost is given.

Reducing the Cost of Tunnel Work with Blasting Gelatine.—Engr.-Contr. Feb. 13, 1909, ½ p.

Shows how by a higher explosive than gelatine dynamite, yet an explosive that is safe to handle, the cost of rock excavation in a tunnel was reduced.

Methods of Constructing the Subaqueous Pipe and Electric Cableway Tunnel at Gloucester, Mass.—By Herman W. Spooner. Engr.-Contr., Jan. 20, 1909, 5 pp.

The method of doing the work is described in great detail, every step of plant installation and construction being given, thus making it a valuable article.

Rock Excavation with a Portable Compressor Outfit.—Eng. Rec., Jan. 2, 1909, 1¼ pp.

Describes a portable compressor plant used in New York City for drilling rock in a trench about 3 ft. wide and from 4 to 5 ft. deep. Also gives some cost of the drilling done with the aid of this compressor.

Cost of Excavating a Small Cellar with Drag Scrapers.—Eng.-Contr., Jan. 27, 1909; ½ p.

The cost of the work is given and comment is made on the method used and how the work could have been cheapened.

Methods and Costs of Stripping Iron Ore with a Steam Shovel.—Eng.-Contr. Jan. 27, 1909; 1 p.

Describes the methods used, namely, steam shovels and cars worked on an incline. Gives the cost of this work and also the cost of drilling for blasting, and also the cost of removing the ore by means of steam shovels and derrick skips.

A Sea Level Canal at Panama.—By Henry G. Granger. Bul. Am. I. of Min. Eng., Jan. 1909; 37 pp.

Arguments are presented for a sea level canal, then a plan is suggested whereby the sea level canal can be built as rapidly as the lock canal. For this purpose the author gives the plans of several types of new excavating machines that he believes would cheapen the earth and rock excavation now being done at Panama.

SURVEYING AND DRAFTING.

Notes on Land Surveying in Hawaii.—By Carl B. Andrews. Rose Technic, January, 1909; 4 pp.

Notes and comments of extensive land surveying in these tropical islands are given and the difficulties encountered in such work shown.

The Topographical Survey of the City of Baltimore.—Eng. Rec., Jan. 2, 1909, 1⅔ pp.

A description of the very complete survey of this city that was made a few years ago is given, compiled from a paper on the subject by the present chief engineer, Joseph W. Shirley.

MISCELLANEOUS.

Cost Keeping on Concrete Construction on the C., B. & Q.—By Don F. Mowry. R. R. Age Gaz., Jan. 15, 1909, 1 p.

An account of cost keeping by means of foreman in bridge construction used on this road, with comments on its efficiency.

Forest Conservation—By R. S. Kellogg. N. E. W. W. Asso. December, 1908, 5 pp.

Shows we are living in a wood using age, hence our forests are being depleted. Discusses the effect of forest cutting upon the

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A Plea for the Business Training of the Engineer.—By R. A. Ross. Can. Engr., Jan. 1, 1909; 1½ pp.

Reprinted from Applied Science. Deals with the results the engineer has to accomplish and shows that he needs a business training as well as a technical training.

A Laboratory for Public Service.—By Arthur D. Little. Can. Eng., Jan. 8, 1909; 2 pp.

A paper read before the Mass. Inst. of Technology showing the place a research laboratory of applied chemistry is taking in engineering matters and what the results obtained from such a laboratory may mean to the country.

Observation on Blasting with High Explosives.—By E. M. Weston. Min. World, Jan. 9, 1909; 2⅓ pp.

An attempt is made to obtain some theory for blasting from the book on the "Blasting of Rock," by A. and Z. Daw. The mathematical proofs are not given.

Waterproofing a Solid Floor Bridge.—Eng. Record, Jan. 16, 1908; ⅓ p.

Describes a method of waterproofing a solid floor railroad bridge built of concrete.

The Method of Making and Placing Pile Protection at Everett, Wash.—Eng. Rec., Jan. 16, 1909; 1½ pp.

Describes the method used in protecting piles with concrete and shows the method of making this concrete protection.

Steel Piling at Power House Intakes at Omaha.—Eng. Rec., Jan. 2, 1909; 1 p.

In this article the work of building several intakes is described, showing the method used in their construction, especially in reference to steel piling.

The Stability of Walls.—By Henry Adams. Surveyor, Jan. 15, 1909; 5 pp.

A paper read before the English Society of Architects. In it the author discusses the general principles for determining the stability of walls.

A New Viewpoint of the American Portland Cement Industry.—By Edwin C. Eckel. Eng. Rec., Jan. 9, 1909; 3 pp.

A paper read before the Association of Cement Manufacturers, in which the future growth of the industry, the regulation of prices, the influence of patents, the marketing conditions, export trade and other features of the industry are discussed.

Methods and Cost of Placing Puddle in a Cofferdam by Pumping.—Eng.-Contr., Jan. 6, 1909; 1 p.

This article describes the methods of placing puddle in a cofferdam 1,085 ft. long, and containing 5,784 cu. yds. of puddle material. The plant used is itemized and the cost of the work is stated.

The Young Civil Engineer.—By E. W. Stern. Eng.-Contr., Jan. 27, 1909; 2⅔ pp.

Reprint of a lecture given by Mr. Stern giving important and valuable advice to guide the young civil engineer who is starting out into practical work.

Methods of Weighing Stone on Barges and Scows.—By H. F. Alexander. Eng.-Contr., Jan. 27, 1909.

Describes the method of weighing stone by loading it onto the barges and then determining the weight by the amount of water displaced. Gauges were attached to the barges in such a way that the weight of the load could be read directly from them.

Waterproofing Detroit River Tunnel.—By R. G. Wright. W. P. & F. P., January, 1909; 1½ pp.

Gives the specifications for waterproofing this tunnel, and the methods used in doing the work, with the plant used for same.

Some of the Recording Systems of a Large Engineering Corporation.—Eng. Rec., Jan. 30, 1909; 1½ pp.

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On the Systematic Training of Engineers: Are We Practical?—By Charles A Bowman. Can. Eng., Jan. 22, 1909, 1½ pp.

Makes a plea for a more practical education and training of the engineer, and states the hard practical work of the engineer must be given to him while young otherwise he would refuse to endure the hardships of such a training.

BOOK REVIEWS.

Applied Mechanics for Engineers.—A Textbook for Engineering Students.—By E. L. Hancock, Asst. Professor of Applied Mechanics, Purdue University. New York: The MacMillan Co., cloth, 5x7¾ ins.; pp. 385, illustrated; $2.

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Cloth, 6x9 inches; 184 pages; illustrated; $2.50.

This book contains the results of tests made during the past fifteen years on cements and cement products, and gives these results in tables and diagrams classified according to subjects. It is a reference book that should be in the library of every civil engineer. The contents include chapters on Chemical Properties of Cement, Physical Tests of Cement, General Physical Properties, Elastic Properties in General, Tensile Properties, Compressive Properties, Flexural Properties, Report on Uniform Tests of Cement by the Special Committee of the American Society of Civil Engineers, and Constitution of Cement.

"Handbook of Cost Data"

BY HALBERT P. GILLETTE, M. Am. Soc. C. E.

Flexible leather, gilt edges; 622 pages; illustrated; $4.00.

This book has over 600 pages of actual costs taken from the private records of engineers and contractors, and so itemized and analyzed as to be of practical working value to any person who has to do with making bids and estimates or in checking estimates. The records cover the whole field of contract work, giving the cost of labor and materials required for every kind of construction. No detail of contract work has been too small to be described and recorded. Wages and prices of material are given in every case, so that proper substitution can be made where conditions differ. It gives also valuable data on methods of construction, thus enabling foremen to handle work in the most economical manner possible. Over 14,000 copies of this book have been sold in two years. The general headings are:

Cost-Keeping, Preparing Estimates, Organization of Forces, etc. —Cost of Earth Excavation—Cost of Rock Excavation and Crushing—Cost of Roads, Pavements and Walks—Cost of Stone Masonry —Cost of Concrete Construction of All Kinds—Cost of Water-Works—Cost of Sewers, Conduits and Tile Drains—Cost of Piling, Trestling and Timberwork—Cost of Erecting Buildings—Cost of Steam and Electric Railways—Cost of Bridge Erection and Painting—Cost of Railway and Topographic Surveys—Cost of Miscellaneous Structures.

"Engineering Work in Towns and Cities"

BY ERNEST McCULLOUGH, C. E.

Cloth, 480 pages; illustrated; price $3.00.

This volume takes up the various classes of engineering work called for in carrying out the public works in towns and small cities and discusses each in a practical way for the use of the city engineer and superintendent of public works. Methods of performing work are described plainly and the book is filled with hints and details so necessary to know and so generally neglected in treatises on city engineering.

"Theory and Design of Reinforced Concrete Arches"

BY ARVID REUTERDAHL, Sc. B., A. M.

(Assistant City Engineer, Spokane, Wash.)

Cloth, 6x9 ins.; 140 pages; illustrated; $2.00.

Of all the problems in bridge designing the analysis of the elastic arch is by far the most difficult. The works which have heretofore appeared on this subject are either so mathematically abstruse or leave so much to the reader to demonstrate for himself that they are of little value to the practical engineer or to the technical student whose mathematical training has not been of exceptional order. This book remedies these faults. The analysis is graphical. Every principle involved is explained thoroughly; there are no missing steps. The result is for the first time a treatise on the elastic arch which can be read and understood by the general practitioner.

"Solid Bitumens, Their Physical and Chemical Properties and Chemical Analysis, Together With a Treatise on the Chemical Technology of Bituminous Pavements

BY S. F. PECKHAM, A. M.

(In preparation; ready soon.)

(Chemist to the Commissioner of Accounts, City of New York.)

(Member of the American Philosophical Society, the Society of Chemical Industry, the American Chemical Society, etc.)

The author of this book has been experimentally studying bitumens for a period of 40 years, and this book embodies the results of his deductions and studies. While the book thus represents the personal labors of a lifetime, a voluminous treatise in themselves, the author's aim has been not only to give first hand studies and results but also to present fully the work of others in the same field. The result has been a treatise on the subject of solid bitumens that is comprehensive, scientific and thorough in a remarkable degree. This book is the most notable contribution to practical chemical technology that has been written in recent years.

"Field System"

BY FRANK B. GILBRETH.

200 pages, with illustrations; bound in leather; $3.00.

This book was written by one of the largest general contractors in the world, and contains nearly 200 pages of rules and instructions for the guidance of his foremen and superintendents. It is the outgrowth of over 20 years of experience in the contracting business and embodies scores of suggestions for economizing and for increasing the output of the men on the job. Mr. Gilbreth is the contractor who made the "Cost-plus-a-fixed-sum-contract" famous; in doing so, he has likewise made famous Gilbreth's "Field System," only a few excerpts from which have heretofore appeared in print.

In making public his "Field System," Mr. Gilbreth is performing a service to the public that is comparable with the action of a physician in disclosing the secret of his success in curing a disease. The disease that Gilbreth's "Field System" aims to cure is the hit or miss method of doing contract work.

Other New and Standard Books

BERG.—"Timber Test Record." 57 pages, 20 tables, paper....	$0.50
FISH.—"Mathematics of the Paper Location of a Railroad"....	0.25
INSKIP.—"Tables of Five Place Logarithms and Five Place Squares, From 0 to 100 Feet by Thirty-seconds of an Inch, With Tables of Logarithmic Secants, Natural and Logarithmic Functions," Etc. Flexible leather; 6x7½ ins.; 280 pages..............................	3.00
GILLETTE.—"Earthwork and Its Cost." Cloth, 5x7½ ins.; 260 pages; 50 illustrations	2.00
"Economics of Road Construction." Cloth, 50 pages; illustrated..............................	1.00
"Rock Excavation—Methods and Cost." Cloth, 5½x7 ins.; 384 pages; illustrated	3.00
MAYER.—"Telephone Construction — Methods and Cost." Cloth, 6x9 ins.; 300 pages; 100 illustrations; 157 tables....	3.00
GILBRETH.—"Bricklaying System." (In preparation; ready soon.)	
McCULLOUGH.—"Engineering Contractor's Pocket Book." (In preparation; ready soon.)	
TAYLOR.—"Surveyor's Handbook." Flexible leather; 4½x7 ins.; 328 pages; illustrated..............................	2.00
SEELEY.—"How to Become an Inspector on Public Works." (In preparation; ready soon.)	

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CONTRACT NEWS

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We shall welcome any news notes that our readers may send in. Notes of contracts awarded, bidding prices, etc., will be especially acceptable.

BIDS ASKED

Bridges.

Bids Open.		See Issue.
Feb. 3.	Corydon, Ind.	Jan. 27
Feb. 3.	Toledo, O.	Feb. 1
Feb. 5.	Toledo, O.	Jan. 27
Feb. 5.	Cincinnati, O.	Jan. 20
Feb. 6.	Mena, Ark.	Jan. 20
Feb. 6.	Cuero, Texas	Jan. 27
Feb. 6.	Richmond, Ind	Feb. 3
Feb. 9.	Lawton, Okla.	Jan. 27
Feb. 10.	Fort Des Moines, Ia.	Jan. 27
Feb. 12.	Grand Forks, N. Dak.	Jan. 27
Feb. 15.	Norwalk, O.	Jan. 27
Feb. 15.	Lisbon, O.	Jan. 27
Feb. 15.	Lynchburg, Va.	Feb. 3
Feb. 16.	Waseca, Minn.	Jan. 27
Feb. 20.	Cleveland, O.	Jan. 27
Mar. 2.	Faulkton, S. Dak	Feb. 3
Mar. 4.	Paris, Ark.	Jan. 13
April 5.	Harrisburg, La.	Feb.

Buildings.

Feb. 3.	Binghamton, N. Y.	Jan. 27
Feb. 3.	Albany, N. Y.	Jan. 27
Feb. 3.	Kansas City, Mo.	Jan. 27
Feb. 4.	San Antonio, Texas	Dec. 30
Feb. 4.	West Durham, N. C.	Jan. 20
Feb. 5.	Danville, Va.	Jan. 27
Feb. 5.	Danville, Va.	Feb. 3
Feb. 5.	Fort Barrancas, Fla.	Feb. 3
Feb. 6.	Reading, O.	Jan. 27
Feb. 6.	Welch, W. Va.	Jan. 20
Feb. 8.	Columbus Barracks, O.	Jan. 20
Feb. 9.	Fort Myer, Va.	Jan. 20
Feb. 9.	Athens, O.	Jan. 20
Feb. 9.	Pleasant Ridge, O.	Feb. 3
Feb. 10.	National Soldiers' Home, Va.	Jan. 20
Feb. 10.	Stanford, Ky.	Jan. 20
Feb. 10.	Brooklyn, N. Y.	Feb. 3
Feb. 11.	Dulce, N. Mex.	Jan. 13
Feb. 11.	Clarinda, Ia.	Jan. 13
Feb. 11.	Madisonville, Tenn	Jan. 20
Feb. 11	Fort Slocum, N. Y.	Feb. 3
Feb. 11.	Washington, D. C.	Feb. 3
Feb. 12.	Cleveland, O.	Feb. 3
Feb. 12	Fort Oglethorpe, Ga	Feb. 3
Feb. 13.	Watkins, N. Y.	Jan. 27
Feb. 13.	Fort Niagara, N. Y.	Feb. 3
Feb. 15.	Fort Monroe, Va.	Jan. 27
Feb. 15.	Grand Rapids, Mich	Jan. 13
Feb. 15.	Shenandoah, Ia.	Jan. 13
Feb. 15.	Fort Dupont, Del.	Jan. 20
Feb. 15.	Grand Rapids, Mich.	Jan. 20
Feb. 15.	Patton, Cal.	Feb. 3
Feb. 15.	Brawley, Cal.	Feb. 3
Feb. 16.	Youngstown, O.	Jan. 27
Feb. 16.	Washington, D. C.	Jan. 20
Feb. 16.	Wheeling, W. Va.	Feb. 3
Feb. 16.	San Bernardino, Cal	Feb. 3
Feb. 17.	Redfield, S. D.	Jan. 20
Feb. 17.	Salisbury, N. C.	Jan. 20
Feb. 17	Anadarko, Okla.	Feb. 3
Feb. 17.	Great Falls, Mont	Feb. 3
Feb. 17	Richmond, Ky.	Feb. 3
Feb. 18.	Greenville, Miss.	Jan. 20
Feb. 18.	Newton, Ia.	Jan. 27
Feb. 19	Fort D. A. Russell, Wyo.	Feb. 3
Feb. 20.	Bar Harbor, Me.	Jan. 20
Feb. 20.	Americus, Kan.	Feb. 3
Feb. 23.	Fort Riley, Kan.	Jan. 27
Feb. 23.	Abilene, Tex.	Feb. 3
Feb. 23.	Dodge City, Kan.	Feb. 3
Feb. 23.	Los Angeles, Cal.	Feb. 3
Feb. 24	Sigourney, Ia.	Jan. 27
Feb. 24	Washington, D. C.	Feb. 3
Feb. 27.	La Salle, Ill.	Jan. 13
Mar. 1.	Omaha, Neb.	Jan. 6
Mar. 1	Gadsden, Okla.	Feb. 3
Mar. 2.	Atlanta, Ga.	Feb. 3
Mar. 3.	Augusta, Me.	Feb. 3
Mar. 8	Atlanta, Ga.	Feb. 3

Roads and Streets.

Feb. 3.	Cleveland, O.	Jan. 6
Feb. 3.	Bluffton, Ind.	Jan. 13
Feb. 3	Kokomo, Ind.	Jan. 20
Feb. 3	Brooklyn, N. Y.	Jan. 27
Feb. 3.	Muncie, Ind.	Jan. 27
Feb. 3.	Logansport, Ind.	Jan. 27
Feb. 3	Bloomington, Ind.	Jan. 27
Feb. 4.	Frankfort, Ind.	Jan. 20
Feb. 4	Frankfort, Ind.	Jan. 20
Feb. 4.	Rockville, Ind.	Jan. 27
Feb. 4.	Laporte, Ind.	Jan. 27
Feb. 4.	Blufftown, Ind.	Jan. 27
Feb. 4.	Bluffton, Ind.	Jan. 27
Feb. 4	St. Paul, Minn.	Feb. 3
Feb. 4	Downers Grove, Ill.	Feb. 3
Feb. 5.	Lebanon, Ind.	Jan. 13
Feb. 5.	Anderson, Ind.	Jan. 13
Feb. 5.	Cincinnati, O.	Jan. 20
Feb. 5.	St. Louis, Mo.	Jan. 27
Feb. 5.	Tipton, Ind.	Jan. 27
Feb. 5.	Cleveland, O.	Feb. 3
Feb. 5.	Pittsburg, Pa.	Feb. 3
Feb. 6.	Terre Haute, Ind.	Jan. 27
Feb. 8.	Indianola, Ia.	Jan. 27
Feb. 8.	Franklin, Ind.	Jan. 27
Feb. 8.	Atlantic City, N. J.	Feb. 3
Feb. 10.	Baltimore, Md.	Feb. 3
Feb. 11.	Appleton, Wis.	Dec. 30
Feb. 12.	Lafayette, Ind.	Feb. 3
Feb. 15.	Whipple Barracks, Ariz.	Jan. 27
Feb. 15.	St. Paul, Minn.	Feb. 3
Feb. 15.	Paris, Ill.	Feb. 3
Feb. 15.	Upland, Cal.	Feb. 3
Feb. 16.	Milford, O.	Feb. 3
Feb. 18.	Spencer, Ind.	Jan. 27
Feb. 18.	Spencer, Ind.	Jan. 20
Feb. 18.	Greenwood, S. C.	Feb. 3
Feb. 18.	Oakwood, O.	Feb. 3
Feb. 18.	Greenfield, Md.	Feb. 3
Feb. 25.	Fort Williams, Me.	Feb. 3
Mar. 2.	Bloomington, Ind.	Jan. 27

Sewers.

Feb. 3.	Brooklyn, N. Y.	Jan. 27
Feb. 3.	Chicago, Ill.	Feb. 3
Feb. 3.	Birmingham, Ala.	Feb. 3
Feb. 5.	Louisville, Ky.	Jan. 27
Feb. 5	Pittsburg, Pa.	Feb. 3
Feb. 8.	College Hill, O.	Jan. 20
Feb. 8.	Zanesville, O.	Feb. 3
Feb. 9.	Niagara Falls, N. Y.	Feb. 3
Feb. 10.	Detroit, Minn.	Jan. 27
Feb. 10.	Brooklyn, N. Y.	Feb. 3
Feb. 11.	Brantford, Ont.	Jan. 27
Feb. 15.	Santa Cruz, Cal.	Feb. 3
Feb. 15.	Atlanta, Ga.	Feb. 3
Feb. 16.	Ashtabula, O.	Jan. 27
Feb. 17.	East St. Louis, Ill.	Jan. 20
Feb. 17.	Baltimore, Md.	Feb. 3
Feb. 20.	Denton, Tex.	Feb. 3

Water Supply.

Feb. 3.	Baltimore, Md.	Jan. 27
Feb. 4.	Minot, N. Dak.	Jan. 20
Feb. 5.	Key West, Fla.	Jan. 6
Feb. 5.	Key West, Fla.	Jan. 13
Feb. 8.	Edgmont, S. Dak.	Feb. 3
Feb. 15.	New Ulm, Minn.	Jan. 20
Feb. 15.	Sebree, Ky.	Jan. 20
Feb. 15.	Itta Bena, Miss.	Feb. 3
Feb. 17.	International Falls, Minn.	Feb. 3
Feb. 20.	Webster, N. Y.	Feb. 3
Feb. 23.	Mabton, Wash.	Feb. 3
Feb. 24.	Owosso, Mich.	Feb. 3
Mar. 15.	Wichita, Kan.	Jan. 20

Miscellaneous.

Feb. 3.	Baltimore, Md.	Lighting System, etc.	Jan. 27
Feb. 4.	Pittsburg, Pa.	Garbage Removal	Feb. 3
Feb. 4	Kansas City, Mo.	Dike Work	Feb. 3
Feb. 5.	St. Louis, Mo.	Street Lighting	Jan. 13
Feb. 5	Pittsburg, Pa.	Street Lighting	Feb. 3
Feb. 6.	Boston, Mass.	Wreck Removal	Jan. 20
Feb. 8	Prescott, Ariz.	Fence	Jan. 13
Feb. 9	Houma, La.	Electric Plant	Feb. 3
Feb. 11.	Mobile, Ala.	Pontoons	Jan. 20
Feb. 11	Mont Alto, Pa.	Gas Generator	Feb. 3
Feb. 12.	Milwaukee, Wis.	Concrete Caissons	Jan. 20
Feb. 13.	Hawaii.	Dry Dock	Dec. 9
Feb. 15	Rock Island, Ill.	Street Lighting	Feb. 3
Feb. 16.	Frankfort, Mich.	Pier Work	Jan. 27
Feb. 18	Fort Barrancas, Fla.	F[illegible]	Feb. 3
Feb. 25.	San Francisco, Cal.	Pier	Feb. 3
Mar. 2.	Milwaukee, Wis.	Incineration Plant	Feb. 3

Excavation, Earth and Rock.

Feb. [illegible]	Girard, Ill.	Tile Ditch	Jan. 2[illegible]
Feb. 5	Edinburg, Ill.	Tile Drain	Jan. 27
Feb. 5	Dwight, Ind.	Ditching	Jan. 27
Feb. 6	Atkinson, Ill.	Ditching	Jan. 20
Feb. 6	Newcastle, Md.	Ditch	Feb. 3
Feb. 8	La Junta, Colo.	Embankment	Feb. 3
Feb. 10	Logan, Ia.	Ditch Work	Jan. 6
Feb. 11	Red Lake Falls, Minn.	Ditch Work	Feb. 3
Feb. 11	Redwood Falls, Minn.	Ditch Work	Feb. 3
Feb. 12	Dakotah, Ia.	Ditch Work	Feb. 3
Feb. 15	Valparaiso, Ind.	Ditch Work	Feb. 3
Feb. 18	Fowler, Ind.	Ditch Work	Jan. 27
Feb. 19	Elbow Lake, Minn.	Ditch Work	Feb. 3
Feb. 23	Harvel, Ill.	Ditch Work	Feb. 3
Mar. 2	Fairmont, Minn.	Ditch Work	Feb. 3

Materials, Machines, Supplies, Etc.

Feb. 2	Saskatchewan, Sask.	Boilers	Jan. 27
Feb. 3	Buffalo, N. Y.	Engine, Dynamo	Jan. 27
Feb. 3.	Chicago, Ill.	Transformers, Watermeters	Jan. 27
Feb. 3.	Baltimore, Md.	Tile	Jan. 27
Feb. 4	Duluth, Minn.	Corporation Cocks	Feb. 3
Feb. 5	Key West, Fla.	Condenser, Filter, Etc.	Jan. 6
Feb. 5.	Banff, Alberta	Sewer Pipe	Jan. 13
Feb. 5.	Pittsburg, Pa.	Castings	Feb. 3
Feb. 6	Lorain, O.	Pump	Jan. 27
Feb. 8.	Washington, D. C.	Drills, Valves, Etc.	Jan. 20
Feb. 8	So. St. Paul, Minn.	[illegible] Pumps	Feb. 3
Feb. 9	New York, N. Y.	Broken Stone	Jan. 27
Feb. 10	Phoenix, Ariz.	Pumping Engine	Jan. 27
Feb. 10	Baltimore, Md.	Tile	Feb. 3
Feb. 1[illegible]	Baltimore, Md.	Electric Light Posts, Etc.	Feb. 3
Feb. [illegible]	Indianapolis, Ind.	Asphalt	Feb. 3
Feb. 11	Kansas City, Mo.	Water [illegible]	Feb. 3
Feb. 11	Duluth, Minn.	[illegible]	Feb. 3
Feb. 11	Washington, D. C.	Rope, Pumps, Hose, Etc.	Feb. 3
Feb. 15	Superior Entry, Wis.	Piles	Jan. 20
Feb. 15	Savannah, Ga.	Paving Brick	Jan. 27
Feb. 15	Washington, D. C.	Track Supplies	Jan. 27
Feb. 17	Milwaukee, Wis.	Gas Producer and Gas Engine, Electric Light Plant	Jan. 13
Feb. 22	Winnipeg, Man.	Pump Motor	Dec. 9
Feb. 2[illegible]	Washington, D. C.	Block, [illegible], Etc.	Feb. 3
Mar. 1	Lethbridge, Alberta	Electrical Mach., Etc.	Jan. 27

BIDS ASKED

Bridges.

Bids are asked for the following work, the items being arranged alphabetically by states.

Upland, Cal—See under Bids Asked—Roads and Streets.

Richmond, Ind—Until [illegible] Feb. [illegible] by D. S. Coe, County Auditor, for repairing the Commons Bridge in Center Township.

Harrisonburg, La—Until noon, March [illegible], by the Police Jury, for steel bridge over [illegible] Bayou, near Harrisonburg. Bidder to furnish his own plans. Bids are also asked for repair of steel bridge at [illegible]. H. W. Ballard, Clerk Police Jury.

Toledo, O—Until noon, Feb. [illegible], by Board Public Service, [illegible] Volk, Secretary, for labor and materials for the repairs to the Cherry St. bridge over Maumee River. The work comprises the furnishing of all labor and material for placing additional floor beams in the two Water St. spans and for placing additional floor-beam hangers for six spans.

Faulkton, S. Dak.—Until Mar. 2, by W. H. Race, County Auditor, for one steel bridge 70 ft. long across the Nixon River and one steel bridge 100 ft. long across the Nixon River.

Lynchburg, Va.—Until 3 p. m., Feb. 15, by Council Committee on Streets and Sewers, H. L. Shaner, City Engineer, for constructing a reinforced concrete viaduct. The work includes 1,600 cu. yds. excavation, 220 tons of steel bars, 3,700 cu. yds. concrete, 1,040 sq. yds. of brick pavement.

Buildings.

Bids are asked on following work, the notes being arranged alphabetically by states:

Gadsden, Ala.—Until 3 p. m., Mar. 1, by James Knox Taylor, Supervising Architect, Washington, D. C., for the construction (complete) of the U. S. Post Office at Gadsden.

Brawley, Cal.—Until 7:30 p. m., Feb. 15, by Trustees of School District, Mrs. D. L. Boyd, Clerk, for constructing a 10-room school building. B. M. Morris, Architect, 608 Grosse Bldg., Los Angeles, Cal.

Los Angeles, Cal.—Until 2 p. m., Feb. 23, by County Supervisors, C. G. Keyes, Clerk, for the construction of a building to be used as a hall of records and county office buildings, Hudson & Munsell, Architects, Nos. 415-417 Stimson Bldg. Contractors are invited to submit bids on separate contracts as follows: (1) Contract for structural steel, (2) contract for foundation and excavation, (3) general building contract, (4) contract for elevators, (5) contract for plumbing, drainage and sewer work, (6) contract for electrical and telephone work.

Patton, Cal.—Until 8 p. m., Feb. 15, by Lyman M. King, Secretary of the Board of Managers of the Southern California State Hospital, Redlands, Cal., for erection of a receiving building at the Southern California State Hospital at Patton, Cal.

San Bernardino, Cal.—Until 7:30 p. m., Feb. 16, by Board of Education, F. W. Conrad, Clerk, for the construction of a technical school building. F. S. Allen, Architect, 712 Security Bldg.

Washington, D. C.—Until 2 p. m., Feb. 11, Bernard R. Green, Superintendent of Construction, Office of Building for National Museum, Library of Congress, for furnishing, delivering and hanging in place complete the fireproof doors and trims required for the new building for the National Museum.

Washington, D. C.—Until noon, Feb. 24, by H. L. Pettus, Constructing Q. M., Takoma Sub-Station, Washington, for installing door and window screens and awnings at the Walter Reed Army General Hospital, Washington.

Fort Barrancas, Fla.—Until 11 a. m., Feb. 5, by A. L. Rhodes, Constructing Q. M., for constructing, plumbing, heating and electric wiring one artillery barrack, one lavatory, one mess hall, one double set firemen's quarters at Fort Barrancas, Fla. Bids are also asked for one double set firemen's quarters at Fort Pickens, Fla.

Atlanta, Ga.—Until 3 p. m., Mar. 2, by James Knox Taylor, Supervising Architect, Washington, D. C., for the installation of a conduit and electric wiring system for the U. S. Post Office and Court House building at Atlanta, Ga.

Atlanta, Ga.—Until 3 p. m., Mar. 8, by James Knox Taylor, Supervising Architect, Washington, D. C., for the installation of the low pressure steam heating and ventilating apparatus, etc., for the U. S. Post Office, Court House, etc., building at Atlanta, Ga.

Fort Ogelthorpe, Ga.—Until 11 a m., Feb. 12, by Capt. John M. Morgan, Constructing Q. M., Fort Ogelthorpe, Ga., for enlargement of storage room in acetylene gas plant at Fort Ogelthorpe.

Americus, Kan.—Until Feb. 20, by H. W. Brinkman, Architect, Emporia, Kan., for the erection of the M. E. Church at Americus.

Dodge City, Kan. Until noon, Feb. 23, by the Chief of the Weather Bureau, Washington, D. C., for the erection of a 2-story and cellar brick building for the Weather Bureau, U. S. Department of Agriculture, at Dodge City.

Richmond, Ky.—Until Feb. 17, by Board of Regents of the Eastern State Normal School, Richmond, at office of Anderson & Frankel, Lexington, Ky., Architects, for constructing a heating and lighting plant and manual training building and distributing system and heating appliances for University Hall, at Richmond.

Augusta, Me.—Until 3 p. m., Mar. 3, by James Knox Taylor, Supervising Architect, Washington, D. C., for the construction complete (except elevator) of an extension to the U. S. Post Office, Court House, etc., at Augusta, Me. The above item appeared in our Jan. 27 issue with city given as Augusta, Ga.

Great Falls, Mont.—Until Feb. 17, by Trustees of School No. 1, Cascade County, A. E. Cary, Clerk, for the construction of two school buildings.

Brooklyn, N. Y.—Until 11 a. m., Feb. 10, by Bird S. Coler, Borough President, for labor and material for repairs and' alterations to lighting and power equipment of Disciplinary Training School.

Fort Niagara, N. Y.—Until 10 a. m., Feb. 13, by the Quartermaster, for constructing and plumbing lavatory building at this post.

Fort Slocum, N. Y.—Until 10 a. m., Feb. 11, by Capt. Peter Murray, Constructing Q. M., for installing electric wiring and fixtures in drill hall and gymnasium.

Cleveland, O.—Until noon, Feb. 12, by Carl Leronz, Secretary Library Board, for construction of a library building at the corner of Clark Ave. and Scranton Road, S. W. Whitfield & King, Architects, 160 5th Ave., New York, N. Y.

Pleasant Ridge, O.—Until noon, Feb. 9, by Board of Education, H. W. Taylor, Clerk, at office of C. C. & E. A. Weber, Architects, St. Paul Bldg.. Cincinnati, O., for erecting new school building for this village.

Anadarko, Okla.—Until 2 p. m., Feb. 17, by the Commissioner of Indian Affairs, Washington, D. C., for the construction of employes' quarters at Riverside School, Kiowa Agency, Okla. Further information may be obtained from Ernest Stecker, Superintendent, Anadarko, Okla.

Abilene, Tex.—Until noon, Feb. 23, by the Chief of the Weather Bureau, Washington, D. C., for the erection of a 2-story and cellar brick building for the Weather Bureau, U. S. Department of Agriculture, at Abilene, Tex.

Danville, Va.—Until Feb. 5, by Board of School Trustees, for erection of new school house to cost $40,000.

Wheeling, W. Va.—Until 3 p. m., Feb. 16, by James Knox Taylor, Supervising Architect, Washington, D. C., for alterations to the 12th St. entrance of the U. S. Post Office, Court House and Custom House at Wheeling.

Fort D. A. Russell, Wyo.—Until 9:30 a. m., Feb. 19, by Capt. V. K. Hart, Constructing Q. M., Keefe Hall, Cheyenne, Wyo., for constructing, plumbing, heating, electric wiring and electric fixtures for the following buildings at Fort D. A. Russell: Two dispensaries, plan No. 247, one or two quartermasters' stables, plan No. 139-L.

Roads and Streets.

Bids are asked on following work, the notes being arranged alphabetically by states:

Upland, Cal.—Until 7:30 p. m., Feb. 15, by City Trustees, R. C. Norton, City Clerk, for improvement of Euclid Ave., the work including 3½ miles of macadam pavement, 18 ft. wide, bordered on each side by oil-tamped pavement, 6 ft. in width; 3½ miles of rough cobblestone gutter, 7 ft. in width, and 15 concrete arched bridge culverts, 25 ft. in length, of Design 1; also 5 concrete arched bridge culverts of Design 2.

Downers Grove, Ill.—Until 7:30 p. m., Feb. 4, by Board Local Improvements, J. W. Hughes, President, for street improvement work to include about 27,011 cu. yds. of earth excavation for parkways, 45,595 sq. yds. of vitrified brick pavement, 116 storm water inlets to be adjusted to grade, 66 storm and sanitary manhole covers to be adjusted to grade.

Paris, Ill.—Until Feb. 15, by Board Local Improvements, Walter Logan, Clerk, for constructing about 21,000 sq. yds. of brick pavement.

Lafayette, Ind.—Until 10 a. m., Feb. 12, by Jno. P. Forsman, County Auditor, for constructing two gravel roads.

Fort Williams, Me.—Until 10 a. m., Feb. 25, by Capt. F. J. Morrow, Constructing Q. M., Portland, Me., for constructing concrete walks at Fort Williams, Me.

Baltimore, Md.—Until 11 a. m., Feb. 10, by Wm. S. Manning, General Superintendent of Parks, Druid Hill Park, for regrading, constructing of catch basins, pipe lines, constructing of armored concrete curb and paving Patterson Park Mall and also the path along Mount Royal approach and south boundary of Druid Hill Park from North Ave. to Robert Ave. and thence from southeast end of wall, south boundary of Druid Hill Park to Eutaw Place. Alternate bids are asked on brick and on asphalt block.

Greenfield, Md.—Until 10 a. m., Feb. 18, by Chas. H. Troy, County Auditor, for constructing macadam road on line between Hancock and Marion Counties.

St. Paul, Minn.—Until Feb. 15, by Edward G. Kramer, County Auditor, for macadamizing or graveling Bald Eagle Lake Ave.

St. Paul, Minn.—Until 2 p. m., Feb. 4, by Board Public Works, for wooden sidewalk construction for the season.

Atlantic City, N. J.—Until 8 p. m., Feb. 8, by E. D. Rightmire, City Engineer, for street paving. The work includes 7,203 sq. yds. 6-in. macadam pavement, 4,407 sq. yds. 12-in. Telford pavement, 9,922 sq. yds. vitrified fire clay block pavement and gutters, including concrete foundation; 310 cu. yds. of concrete, not covered by block pavement.

Cleveland, O.—Until noon, Feb. 5, by E. H. McIntosh, Secretary Board Public Service, for grading, curbing and paving with brick on a number of streets.

Milford, O.—Until noon, Feb. 16, by James Sheehy, Village Clerk, for macadamizing portion of pike road through the village.

Oakwood, O.—Until Feb. 18, by Village Clerk, for paving portion of street with brick.

Pittsburg, Pa.—Until 10 a. m., Feb. 5, by Department Public Works, A. B. Shepherd, Director, for grading, curbing and paving with standard street asphalt on Fair Oaks St.; also for grading, curbing and paving with standard street asphalt and block stone on South Negley Ave.

Greenwood, S. C.—Until noon, Feb. 18, by Kenneth Baker, Mayor, for drainage, grading, curbing and paving of the public square with granite block and with either vitrified brick, wood block, asphalt, or bitulithic, the work embracing approximately 21,333 sq. yds. of pavement. Wilson, Sompayrac & Urquhart, Engineers, Columbia, S. C.

Sewers.

Bids are asked on following work, the notes being arranged alphabetically by states:

Birmingham, Ala.—Until noon, Feb. 3, by Maury Nicholson, City Engineer, for constructing certain storm sewer mains and branches at an estimated cost of $175,000.

Santa Cruz, Cal.—Until 9 a. m., Feb. 15, by J. L. Wright, City Clerk, for constructing a sewer system, to include three septic tanks, 62,912 ft. of 6-in., 4,343 ft. of 8-in., 2,290 ft. of 10-in. and 16,834 ft. of 12-in. sewer pipe.

Atlanta, Ga.—Until 3 p. m., Feb. 15, by the Mayor and General Council, for constructing such sewers as may be authorized by the Mayor and General Council for the year 1909, not including such sewers as may be provided for in the proposed bond isue. Also for furnishing the city with cement, sewer pipe and castings for manholes, catch basins, etc., to be used in the constructing of the above sewers. R. M. Clayton, City Engineer.

Chicago, Ill.—Until 11 a. m., Feb. 3, by Board Local Improvements, C. A. V. Standish, Secretary, for 12 contracts for constructing drains, and 14 contracts for constructing pipe sewers.

Baltimore, Md.—Until 11 a. m., Feb. 17, by Sewerage Commission, Harry W. Rodgers, Secretary, 904 American Bldg., for building sanitary sewers, Contract No. 35. The work includes: 26,500 lin. ft. 6-in. pipe house connections, 32,700 lin. ft. 8-in. pipe sewer, 5,450 lin. ft. pipe sewer, 10 to 24 in. in diameter

Itta Bena, Miss.—See under Bids Asked—Water Supply.

Brooklyn, N. Y.—Until 11 a. m., Feb. 10, by Bird S. Coler, Borough President, for constructing sewers in portions of several streets.

Niagara Falls, N. Y.—Until 7:30 p. m., Feb. 9, by Board Public Works, W. D. Robbins, City Engineer, for furnishing materials and the construction of the following work: No. 202, a tunnel trunk sewer from the end of the present tunnel at Sugar St. to Royal Ave. and in Royal Ave. and Royal Ave. extended to Union St. No. 263, a sewer in Union St. from the end of the proposed tunnel to Buffalo Ave.

Zanesville, O.—Until noon, Feb. 8, by Board Public Service, J. T. Hahn, Clerk, for constructing pipe sewer in 5th St. Bond for $500 required with bid.

Pittsburg, Pa.—Until 10 a. m., Feb. 5, by Department Public Works, A. B. Shepherd, Director, for five contracts for constructing 9-in to 24-in pipe sewers.

Denton, Tex.—Until 2 p. m., Feb. 2[illegible], by Ed. F. Bates, Mayor, for bids, one for the city to furnish the vitrified sewer pipe, L's, T's, Y's and curves, delivered f. o. b. Denton, contractors to do the remainder, and one for furnishing the material and constructing a system of sanitary sewers. The work will consist, approximately, of 2,32[illegible] ft. of 15-in., 2,230 ft. of 12-in., 4,265 ft. of 10-in., 4,820 ft. of 8-in., 32,860 ft. 6-in. diameter sewer pipe, with 21 manholes, 68 lampholes, also a 100,000 gallons a day unit of disposal plant, requiring, approximately, 755 cu. yds. earth excavation, 130 cu. yds. concrete, 4,000 lbs. reinforcing steel, 500 cu. yds. screened gravel or broken rock for contact beds; an automatic apparatus for filling and emptying three beds in rotation, etc. N. Werenskiold, Civil Engineer, Dallas, Tex.

Water Supply.

Bids are asked on following work, the notes being arranged alphabetically by states:

Owasso, Mich.—Until 10 a. m., Feb. 24, by Board Public Works, for a complete pneumatic pumping plant for the city. The work includes the providing of an air compressor and receiver, and all necessary devices or appliances for installing an air lift in the wells, together with all necessary steam, air and water piping for the complete plant; also all the labor of installing said plant and laying of necessary water and air lines that are to be laid underground.

International Falls, Minn.—Until Feb. 17, by City Clerk, for installation of a complete system of water works here.

Itta Bena, Miss.—Until 2 p. m., Feb. 15, by Town Council, for constructing complete water works and sewer system. Xavier A. Kramer, Engineer, Magnolia, Miss.

Webster, N. Y.—Until noon, Feb. 20, by Village Trustees, H. C. Belgh, President, for the construction of a complete system of water works, consisting of about six miles of cast iron pipe, pumping station, small reservoir, standpipe, power pumps and other appurtenances. Knight & Hopkins, Engineers, Rome, N. Y.

Edgemont, S. Dak.—Until 8 p. m., Feb. 8, by C. A. Hardy, City Auditor, for constructing water works.

Mabton, Wash.—Until 10 a. m., Feb. 23, by W. H. Ashton, Town Clerk, for constructing water works.

Miscellaneous.

Bids are asked on following work, the notes being arranged alphabetically by states:

San Francisco, Cal.—Pier.—Until 9:15 a. m., Feb. 25, by State Harbor Commissioners, W. L. Thorpe, Secretary, for furnishing materials and constructing Pier No. 34, on the water front of the City and County of San Francisco. The materials to be used in this work will consist of the requisite quantities of fresh-cut, close-grained Douglas yellow fir piles, creosoted piles, merchantable yellow fir lumber, No. 3 Port Orford cedar, staves for cylinders, band iron, Portland cement, sand, crushed rock, reinforcing material, castings, steel I-beams, steel plates and angles, bolts, rivets and spikes, car springs, steel rails and fastenings, glass, window frame, etc.

Fort Barrancas, Fla.—Fence.—Until 11 a. m., Feb. 18, for constructing fences at this post.

Rock Island, Ill.—Street Lighting.—Until Feb. 15, by M. T. Rudgren, City Clerk, for furnishing 300 lights for street lighting by electricity.

Houma, La.—Electric Plant.—Until Feb. 9, by Mayor and Board of Aldermen, for materials for an electric light plant for this city. Anderson Offutt, New Orleans, La., is Engineer.

Kansas City, Mo.—Dike Work.—Until 2 p. m., Feb. 4, by Fire and Water Commissioners, S. J. Armstrong, Secretary, for the construction of revetment work and a pile dike for the protection of the water works intake at Quindaro.

Mont Alto, Pa.—Gas Generators, Etc.—Until 5 p. m., Feb. 11, by Samuel G. Dixon, Commissioner of Health, 1900 Race St., Philadelphia, for the furnishing of all labor and material necessary for the construction of acetylene gas generators, generator houses, etc., for the dining building and infirmary at the Pennsylvania State South Mountain Sanatorium, near Mont Alto, Franklin County, Pa., in accordance with the revised plans and specifications on file at the office of the Commissioner of Health in Harrisburg, Pa.

Pittsburg, Pa.—Garbage Removal.—Until 10:30 a. m., Feb. 4, by Department of Public Safety, Edward G. Lang, Director, for the collection, removal and disposal of garbage, offal, tin cans, dead animals and condemned meat in and throughout the city from Feb. 1, 1909, to Jan. 31, 1910.

Pittsburg, Pa.—Street Lighting.—Until 11 a. m., Feb. 5, by Department Public Works, A. B. Shepherd, Director, for the light, lighting, extinguishing, caring for and keeping in good order and repair and the furnishing of all material necessary to keep in good condition and light the streets, boulevards, alleyways, byways and parks of the City of Pittsburg with arc or incandescent lamps for the term of one year from the date of the execution of the contract.

Milwaukee, Wis.—Incineration Plant.—Until 10.30 a. m., Mar. 5, by Board Public Works, Charles J. Poetsch, Chairman, for constructing and erecting a refuse incineration plant (except the superstructure of the building and the chimney above foundation). Hering & Fuller, Consulting Engineers, 170 Broadway, New York City.

Excavation, Earth and Rock.

Bids are asked on following work, the notes being arranged alphabetically by states:

La Junta, Colo.—Embankment.—Until Feb. 8, by A. Kilgore, Secretary Otero Irrigation District, for the completion of a reservoir embankment at Clear Creek, near Granite, Chaffee County, Colo. Specifications, etc., at office of Secretary, La Junta, Colo., and at the office of George A. Anderson, Consulting Engineer, No. 519 Equitable Bldg., Denver, Colo.

Harvel, Ill.—Ditch Work.—Until 10 a. m., Feb. 23, by J. A. Huber, Clerk of Drainage District, for cleaning out open ditches of Union Drainage District No. 1, the work including 29,920 lin. ft. of main ditch, estimated to require the excavation of 10,860 cu. yds., and 5,890 ft. of lateral ditches, estimated to require the excavation of 1,870 cu. yds. J. W. Dappert, Engineer, Taylorville, Ill.

Newcastle, Md.—Drain.—Until 2 p. m., Feb. 6, by Mauck Drainage Commission, for construction of the Bowers' Drain.

Valparaiso, Ind.—Ditch Work.—Until Feb. 15, by G. F. Stinchfield, County Surveyor, for the construction of the Cain Ditch. The work includes 19,200 lin. ft. of 10, 12, 14, 15, 16 and 18-in. drain tile at an average depth of 5 ft. Certified check for $200 required with bid.

Dakotah, Ia.—Ditch Work.—Until Feb. 12, by J. G. Devine, County Auditor, for the construction of a ditch in Drainage District No. 18, approximating 434,000 cu. yds. of excavation and 48,000 ft. of 8 to 20-in. tile.

Emmetsburg, Ia.—Ditch.—Until 1 p. m., Mar. 3, by S. R. Stedman, County Auditor, for constructing ditch requiring 21,[illegible] ft. of open work and 20,000 ft. of tile.

Elbow Lake, Minn.—Ditch Work.—Until 2 p. m., Feb. 19, by O. E. Wall, County Auditor, for the construction of County Ditch No. 9. The work includes 57,256 cu. yds. of excavation for a main ditch and 2[illegible] cu. yds. for four branches. O. G. Moller, Engineer, Fergus Falls, Minn.

Fairmont, Minn.—Ditch Work.—Until 1 p. m., Mar. 3, by H. P. Edwards, County Auditor, for constructing County Ditch No. 11, consisting of 15½ miles of open ditch, 417,881 cu. yds. of earth to be removed and 27¾ miles of tile, running from [illegible] to [illegible] ft. deep, and approximate amount of tile required as follows: 2,300 ft. of 20-in., [illegible] ft. of 18-in., 7,100 ft. of 16-in., [illegible] ft. of 15-in., 7,800 ft. of 14-in., 19,8[illegible] ft. of 12-in., 28,900 ft. of 10-in., 3,600 ft. of 9-in., 46,935 ft. of 8-in., 2,600 ft. of 7-in., 10,[illegible] ft. of 6-in. The source of main ditch is about one mile from the village of S[illegible] and the outlet about two miles from the village of Ceylon. The average distance that tile must be hauled from the different railroad stations is about 4 miles. The estimated cost of said work and material is $[illegible].

Red Lake Falls, Minn.—Ditch Work.—Until 1 p. m., Feb. 11, by John B. O'Brien, County Auditor, for constructing County Ditch No. 4, requiring [illegible] cu. yds. of excavation and estimated to cost $3,2[illegible].

Redwood Falls, Minn.—Ditch Work.—Until 1 p. m., Feb. 11, by L. P. Larsen, County Auditor, for constructing Judicial Ditch No. 2. The work includes [illegible] ft. of open ditch, requiring [illegible] cu. yds. of excavation and tile laid as follows: [illegible] ft. of 6-in. tile, 11,173 ft. of 8-in. tile and [illegible] ft. of 10-in. tile.

Materials, Machines, Supplies, Etc.

Bids are asked on following work, the notes being arranged alphabetically by states:

Washington, D. C.—[illegible].—Until [illegible] a. m., Feb. 2[illegible], by Capt. F. C. Boggs, General Purchasing Officer Isthmian Canal Commission, for furnishing under Circular 49[illegible] car wheels, [illegible], steam hose, test gauges, hose nozzles, leather belting, cotton waste, [illegible] felt, canvas, cotton thread, [illegible], board, paper, pencil pointers, pencils, paper clips, [illegible] racks, steel tapes, rubber tape, [illegible], varnish, turpentine, grain alcohol, floor wax, coal tar, lubricating grease, sal soda, etc.

Washington, D. C.—Rope, Pumps, Jacks, Etc.—Until 10:30 a. m., Feb. 11, by Capt. F. C. Boggs, General Purchasing Officer, Isthmian Canal Commission, for furnishing under Circular 493 steam pumps, electric motors, wood boring machines, tackle blocks, Manila rope, packing, copper tubing, cast iron and lead pipe, chain, pig tin, fire brick, jacks, push carts, forges, vises, wrenches, hammers, hatchet handles, tamping bars, turn buckles, oil cans, buckets, rivets, bolts, spikes, nails, screws, staples, nuts, washers, steel wire, sandpaper, window glass, gold leaf, arsenate of lead, etc.

Indianapolis, Ind.—Asphalt.—Until 11 a. m., Feb. 10, by Board Public Works, for furnishing city with asphalt for street repair for period of one year. Sam R. Murray is superintendent Municipal Asphalt Repair Plant.

Baltimore, Md.—Electric Light Posts, Etc.—Until 11 a. m., Feb. 10, by William S. Manning, General Superintendent of Parks, Druid Hill Park, for furnishing cast iron electric light posts and cast iron sub-posts for use under water in the swimming pool at Patterson Park.

Baltimore, Md.—Tile.—Until Feb. 1[illegible] (extension of date from Feb. 3), by Board of Awards, J. Barry Mahool, President, for furnishing buff color brick or asphalt tile and block for projected improvements for Park System. Approximately [illegible] brick or asphalt tile and block of equivalent area will be purchased. J. Harry Gross, Park Engineer, Druid Hill Park.

Duluth, Minn.—Corporation Cocks.—Until 4 p. m., Feb. 4, by L. N. Case, Manager Board of Water and Light Commissioners, for the season's supply of corporation and curb cocks.

Duluth, Minn.—Pumps.—Until [illegible] p. m., Feb. 11 (postponement), by L. N. Case, Manager Board of Water and Light Commissioners, for pumps for [illegible] system.

South St. Paul, Minn.—Electric Pump.—Until 3 p. m., Feb. 8, by [illegible] O'Brien, Secretary Board of Education, for furnishing and setting up an electric water pumping apparatus at the new [illegible] building in the [illegible] Ward.

Kansas City, Mo.—Water Pipe.—Until 2 p. m., Feb. 11, by Fire and Water Commissioners, S. J. Armstrong, Secretary, for furnishing and delivering f. o. b. open cars, Kansas City, all the pipe required for the city's use for the year 1909. The following schedule shows the estimated quantities of pipe that will be required: [illegible] Class D pipe, [illegible]-in. metal, [illegible] tons; [illegible] Class D pipe, [illegible]-in. metal, [illegible] tons; 24-in. Class C pipe, [illegible]-in. metal, [illegible] tons; 20-in. Class C pipe, [illegible]-in. metal, 17[illegible] tons; 16-in. Class C pipe, [illegible]-in. metal, 2[illegible] tons; 12-in. Class C pipe, [illegible]-in. metal, [illegible] tons; 10-in. Class C pipe, .62-in. metal, [illegible] tons; 8-in. Class C pipe, .56-in. metal, [illegible] tons; 6-in. Class C pipe, [illegible]-in. metal, [illegible] tons. Total approximately [illegible] tons.

Pittsburg, Pa.—Castings.—Until [illegible] a. m., Feb. 5, by Department Public Works, A. B. Shepherd, Director, for castings for manholes and catch basins for street improvements.

CONTRACTS LET.

The following contracts have been let recently:

San Francisco, Cal.—Sewer.—[illegible], at $[illegible], for constructing sewer in [illegible] Av.

San Francisco, Cal.—Building Work.—[illegible], at $[illegible], for erecting the [illegible] building. [illegible] & [illegible], at $[illegible], for [illegible] at [illegible] and [illegible] Sts.

Jacksonville, Fla.—Garage.—Turner Construction Co., 11 Broadway, New York, for general contract for [illegible] reinforced concrete garage at Jacksonville for Fred [illegible]

Gilbert. Building will be five stories and basement, 102x102 ft., of reinforced concrete throughout. Work will be undertaken shortly.

Pensacola, Fla.—Sidewalks.—Whidden & Kennedy, Birmingham, Ala., at 10 cts. per sq. ft., for constructing sidewalks for this city.

Americus, Ga.—Post Office.—George Becking Chattanooga, Tenn., for erecting U. S. post office building here.

Cedar Rapids, Ia.—Bridges, Sewer.—E. J. C. Bealer, at $1,150, for constructing two concrete bridges in Bever Park. Same contractor was awarded contract for constructing sanitary sewers in Woodlawn Park addition.

Nampa, Idaho—Bridge.—J. H. Forbes & Co., Caldwell, Idaho, for constructing bridge over Indian Creek.

Alton, Ill.—Post Office Building.—C. L. Gray Construction Co., St. Louis, Mo., for constructing new post office building here.

Cairo, Ill.—Pipe Sewers.—Garner & Hanes, at $17,170, for constructing vitrified tile pipe sewers in 34th St. sewer district.

Champaign, Ill.—Bridge. — Paris Bridge Co., at $1,029, for constructing 48 ft. x 14 ft. bridge in Scott Township for county.

Fulton, Ill.—Bridge Work.—A. R. Putnam, at $1,882, for moving two bridges in the Central Drainage District.

Joliet, Ill.—Street Lighting. — Economy Light & Power Co., at $75 per light, for street lighting.

Indianapolis, Ind.—Paving, Etc.—J. W. Abbott, for paving on Washington St. with brick; A. A. Bowen, for paving on Liberty St. with brick; Wm. Holl, for cement walks, curbing and grading on Fernway; American Construction Co., for brick roadway and curb on Muskingum St.; J. W. Abbott, for brick roadway and curb on Missouri St.

Miami, Ind.—Bridge.—Elkhart Bridge Co., Elkhart, Ind., for bridge over Deer Creek, in Miami, Cass County line, Miami County. Miami County Commissioners have awarded contracts for gravel roads as follows: M. A. Boswell, road No. 1, Erie Township, for $7,169; E. S. Felp, of Clinton County, road No. 3, Peru Township, for $7,000, and also road No. 3, Clay Township, for $7,800; W. R. Hines, of Clinton County, road No. 5, Clay Township, for $6,100, and No. 10, Clay Township, for $3,150. Grant County—Grant County Commissioners have awarded contracts for gravel roads as follows: L. P. Simons gravel road, to P. W. Clannin, for $2,750; S. B. Leach road, to P. W. Clannin, for $1,653; D. L. Richards road, to P. W. Clannin, for $2,760; Milton A. Rich road, to John W. Slater, for $7,100; M. S. Dunn road, to John W. Slater, for $1,925; Daniel Siers road, to Dennis Haisley, for $3,989; Charles Winegardner road, to E. W. Malott, for $5,651.17. Under the three-mile law, contracts were let as follows : Sycamore St., Fairmount, to Wm. Yates, Berea stone, at $4.42 per lineal foot; Mill St., Fairmont, F. M. Benner & Co., Berea stone, $4.23 per lineal foot. The two improvements will cost about $27,000.

Michigan City, Ind.—Building. — Henry Koeller, Michigan City, at $36,400, for erecting Y. M. C. A. building here.

Bowling Green, Ky.—Bridge. — Argonia Bridge Co., Lebanon, O., at about $4,000, for constructing new bridge at Mottley's Mill for Warren Fiscal Court.

Abbeville, La.—Church. — Caldwell Bros., for new brick and stone church building to cost $50,000.

Jennings, La.—School.—Innis & Graham, Fort Worth, Tex., for erecting $45,000 public school building here.

Boston, Mass.—Building Work.—George A. Fuller Co., Board of Trade Bldg., at $679,000, for constructing addition to Suffolk County court house.

Chisholm, Minn.—Town Hall.—G. E. Kretz Co., Duluth, Minn., for erecting new $40,000 city hall here.

Hattiesburg, Miss.—Depot.—Jefferson Construction Co., for constructing new passenger station here for the Northeastern R. R.

Winnfield, La.—School House.—John Arthur, Shreveport, La., for erecting new parish school house.

Joplin, Mo.—Viaduct.—Henry L. Doherty & Co., at about $40,000, for constructing 3rd St. viaduct.

Kansas City, Mo.—Comfort Stations.—Carl A. Nelson, at $6,704, for general contract for two comfort stations for the city; and The Colter-McDonnell Co., at $4,401, for the plumbing.

Columbiana, O.—School Building.—Cleveland Fire Proof Construction Co., Cleveland, O., for general contract for construction of new brick school building here. Searles, Hirsch & Gavins, Architects, Cleveland, O.

Columbus, O.—Viaduct Superstructure.—McClintock-Marshall Construction Co., Pittsburg, Pa., at $18,560, for superstructure of Mound St. viaduct.

Toledo, O.—Moving Bridge.—R. W. Johnson, at $1,987, for moving old steel bridge at Detroit Ave.

Youngstown, O.—Building Work.—Niedermier & Restle, Youngstown, for the masonry work, including granite and terra cotta work, and fireproofing, etc., for new Wick Trust Co. building to be erected at Federal and Phelps Sts.

Zanesville, O.—Sewers.—J. E. Brown, at $1,984, for constructing three sewers in Brighton.

Hobart, Okla. Sewers.—T. C. Brooks & Son, Detroit, Mich., for construction of $25,000 worth of additional sewers in the Hill addition.

Danville, Pa.—Sewage Disposal Plant.—Pitt Construction Co., Pittsburg, Pa., at $52,547, for constructing sewage disposal plant at State Hospital for the Insane.

Plymouth, Pa.—Roadwork.—Horn & Neff, Slatington, Pa., at $70,786 for constructing 25,534 ft. of Birdshow trap macadam roads through Plymouth Township to the Hunlock Township Line.

Bamberg, S. C.—City Hall.—B. R. Bandy & Son, Yorkville, S. C., for erecting 3-story city hall building here.

Murfreesboro, Tenn.—Post Office.—W. F. Henry, for erecting new post office building at this city.

Knoxville, Tenn. — Bridges. — Converse Bridge Co., Chattanooga, Tenn., for two steel bridges for county—one at Minot and the other at Wellsville.

Dallas, Tex.—Bridge.—A. S. Adams, for constructing concrete bridge over Turtle Creek at Hall St. for city.

Seguin, Tex.—Church.—John Goodrum, for erecting new Methodist church.

Norfolk, Va.—Rolling Stock.—The receivers for the Seaboard Air Line have awarded contracts for rolling stock aggregating $900,000. The awards were as follows: South Baltimore Steel Car and Foundry Co., 500 thirty-ton steel under frame box cars; Barney & Smith, Dayton, O., 200 fifty-ton steel phosphate cars; Rogers Ballast Car Co., Chicago, 50 fifty-ton ballast cars; Barney & Smith, Dayton, O., 15 passenger cars.

Hayward, Wis.—Bridge.—Minneapolis Steel & Machinery Co., Minneapolis, Minn., at $2,770, for steel bridge with cement floor near this place.

Tacoma, Wash.—Reservoir.—D. A. Williams, for constructing 7,000,000-gallon reservoir for city.

Wausau, Wis.—Heating Plant.—The Andrews Heating Co., Minneapolis, Minn., to construct the central heating plant for the county asylum and almshouse.

Charleston, W. Va.—Sewers.—J. M. Ferry & Sons, for constructing sewers in West Charleston.

Parkersburg, W. Va.—Sewer.—R. T. Martin, at $5,919, for constructing sewers in the 7th and 8th Wards.

Winnipeg, Man.—Power House. — John Gunn & Sons, Winnipeg, at $779,000, for construction, except machinery equipment, of power house for this city.

PROJECTED WORK.

Bridges.

Items Arranged Alphabetically by States.

Phoenix, Ariz.—The Phoenix & South Side Bridge Co., has had plans prepared for a bridge to be built over Salt River south of Phoenix. The estimated cost is $52,000 and the plans call for a steel structure of 11 spans of a total length of 1,155 feet. Ed Wells, Prescott, Ariz., is interested. J. C. McClure, Tucson, Ariz., is engineer.

Aroville, Cal.—Butte county sustained a loss of about $25,000 in damages to bridges by recent floods. The chief loss is in a bridge at Enterprise, which it is estimated will take $10,000 to replace.

Cambridge, Ill.—Supervisors of Henry County have ordered an appropriation to cover half the expense of a bridge over Rock River. The remaining half will be borne by Rock Island county.

Havana, Ill.—The county commissioners of Mason and Cass counties have rejected all bids received for constructing a bridge over the Sangamon River near Chandlerville. The lowest bid was $4,150.

Portland, Ind.—The Lake Erie & Western Ry. Co., J. P. Penwell, Supervisor of Bridges and Buildings, Tipton, Ind., is to erect a new iron bridge in the spring at this city.

Warsaw, Ind.—County commissioners will ask for $10,000 for new bridges.

South Bend, Ind.—County commissioners contemplate constructing a concrete bridge over the river at Logan St., at Mishawaka, Ind.

High Bridge, Ky.—The Cincinnati Southern R. R. (Queen & Crescent System, W. E. Warrington, Chief Engineer, Cincinnati, O.) is preparing to replace the present structure over the Kentucky River at High Bridge with a new structure, which will cost about $1,250,000. The old bridge was 1,238 ft. long.

Frankfort, Ky.—Bill is to come before the State Legislature for the construction of a bridge over the Kentucky River at the foot of Capital Ave. The bridge will cost about $60,000 and will probably be built by the state.

Louisville, Ky.—Special Road Commission, of which R C. Ballard Thurston is chairman, has reported to the county fiscal court that nine county bridges are in very bad condition. Concrete structures are suggested to take their place.

Saginaw, Mich.—The Pere Marquette R. R., A. L. Grandy, Division Engineer, Saginaw, Mich., is to widen its draw span on its maine line bridge over the Saginaw River.

Fergus Falls, Minn.—The City Council is considering constructing a new bridge on Concord St. The bridge will probably be constructed of steel and will cost about $4,000.

St. Paul, Minn.—Ordinance has been before the City Council directing the City Engineer to determine the cost of constructing a viaduct over the St. Paul Short Line tracks on W. 7th St.

Kansas City, Mo.—Resolution has been introduced into the Council by Alderman W. P. Woolf, directing the City Engineer to make an estimate of the cost of a viaduct from 17th and Holly Sts. to 17th and Liberty Sts. across the railroad yards in the West Bottoms.

St. Louis, Mo.—Boller & Hodge, 1 Nassau St., New York, N. Y., have been selected as engineers for the construction of the municipal bridge for this city. They will at once prepare plan for the bridge, which is to cost about $3,000,000. The bridge will be built under the direction of the Board of Public Improvements, of which A. J. O'Reily is President.

Artesia, N. M.—A new bridge is to be built over the Pecos, near this place. J. W. Turknepp is in charge of the construction and W. M. Strong, El Paso, Tex., is Engineer.

Buffalo, N. Y.—The Fort Erie & Buffalo Bridge Co. will apply at the coming session of the Canadian Parliament for an act of incorporation with power to construct and operate a high bridge from Fort Erie, Ont., to the foot of Ferry St. in Buffalo. The Mackenzie & Mann Co., Toronto, Ont., is reported to be interested.

Portland, Ore.—City may vote at the general election on the construction of a $1,500,000 suspension bridge over the Willamette River to land on the east side at E. 9th and Caruthers Sts. The total length will be 4,800 ft.

Camden, S. C.—County Commissioners are considering constructing a bridge across Wateree River.

Tacoma, Wash.—Frank L. Davis, City Engineer, has made plans and estimates for the construction of 5 concrete bridges to be built this summer, provided a $300,000 bond issue is voted.

Milwaukee, Wis.—Resolution is before the Council directing the building of a $6,000 concrete bridge over the Kinnickinnic River at the foot of 6th Ave. Charles J. Poetsch is City Engineer.

Railroads.

Items Arranged Alphabetically by States.

Pyriton, Ala.—The Atlanta, Birmingham & Atlantic R. R., W. A. Kennon, Division Engineer, Fitzgerald, Ga., has been having surveys made for a line from Pyriton, Ala., direct through to Atlanta. It is said that the company is raising funds to begin construction work this year. The above company will also shortly commence work on completion of the tracks from Bessemer to Mulga. Grading is now under way.

Little Rock, Ark.—The Zinc Belt R. R. Co. has filed its articles of incorporation here and proposes to build a line through the heart of the rich zinc belt in the northern tier of counties of Arkansas and eventually extending from Little Rock to St. Louis, Mo.

Oakland, Cal.—The San Francisco, Oakland & San Jose Consolidated Ry., W. F. Kelly, General Manager, Oakland, Cal., has applied to the city council for franchise to connect its Oakland and Berkeley lines by means of a track laid parallel to Lowell St. over private right-of-way.

Placerville, Colo.—J. Carmon Layton, Des Moines, Ia., who has been promoting the project for building a railroad through Paradox Valley, in Montrose County, is stated to have secured $1,000,000 with which to begin work at once. As proposed the work will be from Placerville on the Ouray division of the Denver & Rio Grande to Naturita on the San Miguel river, a distance of 55 miles.

Greeley, Colo.—The Union Pacific, Russell L. Huntley, Chief Engineer, Omaha, Neb., is reported to be planning to have work started early this month on the grading of an extension 35 miles eastward from Greeley to a point 8 miles east of Pierce.

Abbeville, Ga.—The Abbeville & Northwestern R. R. Co. has been incorporated with a capital stock of $100,000 and principal offices in Abbeville. The company proposes to build a line connecting Abbeville, in Wilcox county, with Fort Valley, in Houston county. The length of the proposed line is 58 miles with the branch running to Montezuma, Ga., 17 miles long. The incorporators are J. L. Bankston, W. A. Cherry, T. R. Moye, E. M. Carnes, Hal Lawson, J. B. Girardeau, C. F. Chapman and W. L. Harrell, all of Abbeville, Ga.

Boise, Idaho—The promoters of the proposed Boise-Butte R. R. have succeeded in interesting outside capitalists for the construction of the proposed road. Surveys have been made and it is said that the capital for construction is in a likely way to be secured. Judge J. A. Richards and W. D. Booth of Boise are interested.

St. Paul, Minn.—The Minneapolis, St. Paul & Sault Ste. Marie R. R., Thos. Green, Minneapolis, Minn., Chief Engineer, will, it is reported, build a new line running southwest from Thief River Falls 250 miles to a connection with the Erooton & Duluth line now under construction. It is expected that the new line will be built either this year or the next.

Cameron, Mo.—The Missouri River & Cameron R. R. Co. has been chartered and proposes to build a line 35 miles long from a point on the Missouri river, in Platte county, through Smithsville, in Clay county, to Lathrope, in Clinton county. The capital stock is $350,000. The incorporators are: William W. Lewis, Charles O. French, William A. Medill, Fred M. Titus and U. S. Grant Peabody, all of Kansas City, Mo. The same parties have taken out a charter for the Jackson County Junction R. R. Co., which proposes to build a line in Jackson county. The capital stock of this latter company is $20,000.

Stockville, Neb.—A new farmers' railroad is projected from this place to a connection with the Burlington, which runs a few miles north. The road is expected to cost $100,000. John Sanders, of Stockville, Neb., is interested. The road will be about 7 miles long.

Tucumcari, N. M.—Advices from this place state that work will be resumed shortly on the construction of the Choctaw Ry. branch from Amarillo, Tex., to Tucumcari, N. M. The work was started some years ago and 75 per cent of the grading finished. J. M. Stark, Engineer in Charge of Construction, has opened offices at Tucumcari, N. M., and it is assumed from this that work is to be at once resumed.

Asheville, N. C.—The Carolina & East Tennessee R. R. Co. has applied for a charter and proposes to construct a road between this city and Huntdale. The road if built will pass through Weaverville, Buncombe county, Burnsville, Yancey county, and thence to Huntdale, in Mitchell county. John H. Carter and R. S. Holland of Ashville, N. C., are interested.

Eastland, Tex.—The Eastland, Rising Star & Southern Ry. Co. has been chartered and proposes to construct a railroad from Eastland, in Eastland county, south, crossing the line of the Texas Central R. R., and thence in a southerly direction to Rising Star, in Eastland county, a total distance of 27 miles. The general offices are in Eastland and the capital stock is $100,000. The incorporators are W. S. Michale, J. L. Alford, James Smith, V. R. Coon, Fred M. Delano, J. H. Carter and R. S. Holland of Ashville, N. J. Alford and T. A. Williams.

Orange, Tex.—The Orange & Northwestern R. R. is planning to build an extension at an early date to Marshall, Tex. L. Miller, Orange, Tex., is President.

Altus, Tex.—The Altus, Roswell & El Paso Ry. Co. is stated to have been completely financed and is to have construction work on the line started at several places at once. Part of the road is already under construction and 33 miles of the proposed route have been graded in Oklahoma and 22 miles near Lubbock, Tex. The road is to connect Altus, Oklahoma, with Roswell, N. M., 350 miles distant. Edward Kennedy is President and Edgar Chapman of Clint, Tex., is Secretary.

Jacksboro, Tex.—The Gulf, Texas & Western Ry. Co. has been incorporated in the state of New Jersey with the capital stock of $1,500,000 to build a line from Jacksboro to some point in New Mexico. It is stated that active construction work will be started at Jacksboro shortly. The project is backed by the firm of Morganthal & Co., New York, N. Y., and J. J. Jermyn, of Scranton, Pa.

Plainview, Tex.—The citizens' committee of Plainview, Tex., have accepted the offer of the South Western Construction Co. to build two lines, one southwest and the other southeast, from Plainview. A bonus of $10,000 and right-of-way is to be granted.

Meherrin, Va.—The Raper Jackson Lumber Co. of Norfolk, Va., which is operating extensive lumber mills near this place, is building a railroad from Nutbush on the Virginia R. R. west to its holdings. The line will be 6 miles long and will be built some time this summer.

Appleton, Wis.—The Wisconsin & Northern Ry., according to advices from this place, will have grading started this spring on right-of-way between Appleton and Shawano. W. Campder, Oshkosh, Wis., is Chief Engineer.

Gilmanton, Wis.—The construction of a railroad from Mondovi to Gilmanton is proposed and over $50,000 has been raised for the work. The road will be about 8 miles long. N. C. Foster, Fairchild, Wis., is reported to be interested.

Electric Railways.

Items Arranged Alphabetically by States.

Huntsville, Ala.—The Huntsville, Chattanooga & Birmingham Interurban Ry. Co. is stated to be considering extending its line to the top of Monte Sano.

Pocahontas, Ark.—The construction of an electric railway between this place and Maynard is proposed. Citizens of that place have subscribed $8,250 for the enterprise. It is proposed to extend the line on to Doniphan.

Lewiston, Idaho—M. A. Means of this place has applied for a franchise for a street railway here. The franchise provides for the completion of over one mile of track within the next 8 months and the completion of 3½ miles within 2½ years. Mr. Means is organizing a company with local capital for the construction and operation of the street railway.

Wallace, Idaho—Ordinance has been before the council to grant W. J. Hall and associates a franchise over the streets of this city for the projected Spokane-Coeur d'Alene electric line.

Streator, Ill.—The Illinois Light & Traction Co. is planning to extend its South Illinois St. line for a distance of one mile. The material for the new extension has already been ordered and work will be started in the early spring.

Carlyle, Ill.—Directors of the Carlyle & St. Louis Electric Ry. Co. have decided to at once obtain the right-of-way for an electric line extending from this city to Lebanon and through Beckemeyer, Breese, Aviston, Trenton and Summerfield. Money for the preliminary surveys and work was subscribed about two years ago and surveys made and franchises obtained.

Crown Point, Ind.—Local parties are considering organizing a stock company to build an interurban line between Crown Point and Gary, Ind.

Kokomo, Ind.—Steps are being taken to secure capital for the construction of the Kokomo, Frankfort & Terre Haute Traction line. As proposed the road will be built first between Kokomo and Frankfort. Judge James Kemp of Frankfort, Ind., is interested.

Iowa City, Ia.—Henry Negus of Iowa City and I. N. Hanlel of Tipton, Ia., are promoting a project for a new street railway for Iowa City.

Grundy Center, Ia.—This town has voted a 5 per cent tax and franchise in aid of the Iowa R. R. Co., which proposes to build an electric line from Waterloo to Perry through this place.

Dubuque, Ia.—The Union Electric Co. is planning to make several extensions this fall.

Iola, Kan.—W. Lanning, Tonganoxie, Kan., president of the Kansas City & Kansas Southwestern R. R. Co., has filed a mortgage for $12,000,000 to provide funds for construction of an electric railway between Kansas City and Topeka via Tonganoxie and Lawrence and the building of a line from Lawrence to Independence, Kan. Surveys for the line between Kansas and Topeka and between Ottawa and Independence are stated to have been completed. Surveys are now under way between Ottawa and Lawrence and construction work will start between Kansas City and Topeka March 1, according to a statement of Mr. Lanning.

Girard, Kan.—The Girard Coal Belt Electric Railway System is stated to have been bought by J. J. Heim, [illegible] Natl. Bank Bldg., Kansas City, Mo., President of the Joplin & Pittsburg R. Co. It is understood that he will construct an electric railway connecting the Coal Belt line and the Pittsburg System.

Fenton, Mich.—Chester Bliss of Flint, Mich., treasurer of the Fenton Light & Power Co., has secured right-of-way for an electric road from Fenton to Flint via Long Lake.

Pass Christian, Miss.—Fred M. [illegible], Chief Engineer of the Gulfport & Mississippi Coast Traction Co., of Gulfport, Miss., has started surveys here for the proposed electric railroad to be constructed here.

Missoula, Mont.—Work is to be started shortly here, it is said, on new street car line for this city. J. R. Wharton, Butte, Mont., is interested.

St. Louis, Mo.—City council has passed bill granting a franchise to the Hillsboro, Kimmswick & Northern Electric R. R. Co. allowing it to come into St. Louis with a new electric line from the south. The new road is to terminate near Broadway and Poepping Sts. and will connect Broadway and Bellefontaine lines.

St. Louis, Mo.—The St. Louis, Creve Coeur & Western Ry. Co. of Clayton, Mo., has been granted a franchise for an electric railway from the city limits at Etzel Ave. to Creve Coeur Lake. The road is to have double track and work will be probably started within two months. Richard Stevens, Clayton, Mo., is interested.

Lincoln, Neb.—The Omaha, Lincoln & Beatrice Ry. Co., E. C. Hurd, General Manager, Lincoln, Neb., will build a 3-mile extension to its Bethany line in the early spring. A number of other improvements are also contemplated.

Omaha, Neb.—The Omaha & Council Bluffs St. Ry. Co., H. B. Noyes, Chief Engineer, Omaha, Neb., contemplates a number of improvements for its line this spring. Extensions to Elmwood Park and to Orchard Hill are proposed.

Elizabeth, N. J.—The Traction Development Co. has been incorporated with a capital stock of $100,000 for the purpose of securing franchises, rights-of-way and engineering plans for the Elizabeth & Amboy Traction Co., which proposes a new trolley system to operate between Elizabeth and Perth Amboy. J. A. McClary of Rahway, N. J., has charge of the rights-of-way and engineering plans for the company.

Painesville, O.—An organization has been formed here to secure the construction of an electric line to the south to extend through LeRoy, Windsor and Warren. Right-of-way is to be secured. O. A. Bartlett, LeRoy, O., and J. H. Murray of Painesville, O., are interested.

Dayton, O.—The Dayton & Troy Electric Ry. Co., J. D. Baker, Roadmaster, Tippecanoe City, Ohio, is to build two miles of second track this spring. The company will also build one-half mile of track as an emergency crossing at the grade with the Big Four R. R.

Durant, Okla.—L. S. Powers, Louisville, Ky., is promoting a project for the construction of an interurban electric line to run south to Red River, then east several miles and back to Durant.

Eugene, Ore.—Preliminary surveys have been started for an electric line from Eugene to Florence on the Lane county coast. Franchise for such a line has been asked of the county commissioners. According to the terms of the franchise 15 miles of road must be completed the first year, 25 miles the second year and the entire road built within 3 years. The project is being promoted by Alton Hampton, F. E. Dunn and F. M. Johnson of Eugene, Ore.

Grove City, Pa.—Final surveys have been made for the proposed electric 8-mile electric line between Slippery Rock and Grove City. The project is backed by S. L. McClure, Washington, Pa., and Frank Filer of Mercer, Pa.

Chattanooga, Tenn.—Sam W. Divine has been granted a franchise to construct an electric railway for freight and passenger service from the corporation at Long St. to Fort Oglethorpe. He has also asked franchise for lines in the city.

Wichita Falls, Tex.—Street railway franchise here has been granted to J. A. Kemp and Frank Kell of Wichita Falls. Bond has been executed to have three miles of line in operation within six months. The line is to be built out to Lake Wichita, two miles from the town.

Sewers.

Items Arranged Alphabetically by States.

Little Rock, Ark.—A new sewer district is being formed in the 1st Ward.

Imperial, Cal.—A bond election will be held at an early date to vote on installing a sewer system to cost $40,000.

East San Jose (P. O. San Jose), Cal.—The Town Engineer will shortly complete plans for the proposed sewer system.

Las Animas, Col.—The City Council has passed ordinance authorizing a complete sewer system.

Hartford, Conn.—City Engineering Department is preparing plans for the construction of Section C of the Homestead Ave. intercepting sewer system. The section will cost $9,188.

New Briton, Conn.—City Sewer Department will take up the matter early this spring of building the Black Rock sewer system, which is to cost about $20,000.

Macon, Ga.—The City Council will shortly take up the matter of installing a sewer system for the newly annexed territory of Vineville. The system will cost about $100,000.

Aurora, Ill.—Sewer extensions in the southeast part of the city are to be installed this year and will cost about $60,000, according to the figures of City Engineer Tarble.

Springfield, Ill.—Ordinance has been before the Council for the construction of a sewer in southeast part of the city, to cost not more than $13,460.

Elgin, Ill.—C. E. Plum, City Engineer, has completed plans for the 5th Ward sewer. The sewer will cost about $80,000 and will be 10 miles long. It will serve about 800 residences.

Naperville, Ill.—Hayes & Son, Dunkirk, Ind., were the lowest bidders Jan. 18 for the construction of 56,000 sq. yds. of pavement and curbing and 5 or 6 miles of drainage sewer. Their bid was $77,000.

Belleville, Ill.—Ordinance has been passed providing for a sewer in the Irish Pond district to cost $11,190.

Mendota, Ill.—The construction of a septic tank system for sewer district No. 2 is under consideration. The cost will be about $2,500.

Bloomington, Ill.—Board of Local Improvements has passed resolutions for the construction of several sewers and water mains.

Clinton, Ia.—The city is to have new sewers constructed in blocks Nos. 10, 11 and 39. W. E. Hayes is the City Clerk.

Wichita, Kan.—A sanitary sewer is to be constructed in the river side district.

Hutchinson, Kan.—T. G. Elbury, City Engineer, has prepared plans for sewer extensions involving about 3,500 ft. of 8-in. pipe sewer.

Newton, Kan.—City Engineer McClane is to prepare plans for the proposed South Side sewer and also for the construction of a septic tank for treating all sewage from Districts Nos. 1, 2 and 3.

Louisville, Ky.—C. T. McCracken, Columbus, O., was the lowest bidder Jan. 22 for the construction of Section F of the South Side fall sewer. The contract amounts to about $90,000.

Mansfield, Mass.—Bill is before the State Legislature to authorize this town to construct and maintain a system of sewers.

Cassopolis, Mich.—Plans are being made for a sewer system for this place.. George S. Pearson, Kalamazoo, Mich., is the Engineer.

Grand Rapids, Mich.—Estimates have been submitted to the Board of Public Works by L. N. Andersen, City Engineer, providing for the construction of ½ mile of sewers to cost $28,552. The largest contract calls for a sewer in Tamarack St. to cost $26,975.

Caro, Mich.—The village voted Feb. 1 on bonding for $35,000 for establishing a sewer system. Plans have all been made.

Ypsilanti, Mich.—The City Council has directed the Commissioners of Public Works to procure materials and begin the construction of a sewer in Bell St.

Traverse City, Mich.—The City Council is considering the matter of a sewage disposal plant or a disposal system.

Duluth, Minn.—City Engineer M. C. Gilvray is preparing plans for two trunk sewers to be built this year in West Duluth.

Albert Lee, Minn.—Plans for a trunk sewer have been made for this city and it will cost between $25,000 and $30,000.

Wymore, Neb.—R. C. Markle of this city has made a proposition to the City Council to furnish water supply and put in a sewer system.

Albuquerque, N. Mex.—City has voted to issue bonds for sewer works.

Washington, N. J.—A special election is to be held to vote on installing a sewer system.

Watertown, N. Y.—State Health Department has approved plans for the construction of the Meadow Point, West Miller and Maple St. sewer. Henry E. Baker is City Engineer.

Tonawanda, N. Y.—The Board of Public Works has rejected all bids received Jan. 15 for constructing a sewer for the Gas Town section. New bids will be called for sanitary and storm sewer systems.

Springfield, O.—M. J. Bahin, City Engineer, has been preparing estimates for the proposed South End storm sewer.

Anadarko, Okla.—City has voted $7,000 of bonds for extending its sewer system.

Pittsburg, Pa.—The State Board of Health has directed this city to take immediate steps toward building a new sewage disposal system in order to cease polluting the Ohio River. It is estimated that the project will cost between $15,000,000 and $20,000,000. Ordinances authorizing the making of surveys and the drawing of plans for the new system have been before the City Council. A. B. Sheppard is director, Department of Public Works.

Harrisburg, Pa.—The State Health Department has approved plans for a number of small sewers to be built by this city this year. M. B. Cowden is City Engineer.

Bradford, Pa.—Plans are to be prepared for a sewage disposal plant for this city. A. F. Bannon, Jr., is City Engineer.

Dalhart, Tex.—This city is to construct a sewer system. W. D. Wagner is Mayor.

Dallas, Tex.—A new main line sewer is to be built in the 10th Ward this year.

Barton Heights, Va.—This village, which is a suburb of Richmond, is to have an election on Feb. 23 to vote on a bond issue of $15,000 for building a sewer and water system.

La Crosse, Wis.—The City Engineer is preparing plans for a trunk sewer to extend from 9th and Mississippi to Front and Mississippi Sts. The sewer will be 78 ins. in size and will be constructed of concrete. It will cost about $40,000.

Appleton, Wis.—The city proposes to build a sewer in College Ave. Ravine this year.

Water Supply.

Items Arranged Alphabetically by States.

Auburn, Ala.—Town has voted $12,000 bond issue for water works and sewers.

Ensley, Ala.—Hugh Friel and associates of North Birmingham, Ala., who proposed to build a water works, have applied to the Council of this city for a franchise to run pipes through the city and conduct water works business here.

Samson, Ala.—Howard Butt, 121 Sayre St., Montgomery, Ala., is engineer to construct the water and light system at Samson. Mr. Butt and Mr. W. J. Gresham, Mayor of Samson, would like to correspond with bond companies in regard to selling $25,000 water and light bonds. Mr. Butt would also like to correspond with manufacturers of water and light supplies.

Pueblo, Colo.—W. L. and M. J. Egner of this city have filed plans with the County Clerk for the Egner irrigation reservoir.

Montrose, Colo.—Surveys are in progress for the location and construction of a flume and canal taking water from the San Miguel River for the purpose of irrigating about 50,000 acres of rich mesa lands lying between Norwood and the East Paradox Valley, in the southwestern portion of Montrose County, Colorado. The total length of the canal is approximately 70 miles and its carrying capacity will be 400 cu. ft. per second. Robert McF. Doble, Consulting Engineer, Majestic Building, Denver, is directing the work.

Hartford, Conn.—Water Board is considering installing large mains for fire protection purposes in the district between Park River, Spring, Belden and Edwards Sts.

Gainesville, Ga.—City Council is considering increasing water supply by constructing dam, forming a lake reservoir and installing new pump.

Muscatine, Ia.—Muscatine Water Works Co. is to expend $10,000 on improvements.

Galesburg, Ill.—City is to construct water main in Arthur Ave.

Silvis, Ill.—Board Local Improvements is to call for bids soon for constructing water works.

Logansport, Ind.—Board of Public Works has been asked to extend water mains on 15th St.

Salem, Ind.—Town has voted to enlarge its water system.

Shirley, Ind.—Town votes Feb. 6 on installing water works.

Canton, Kans.—City Council has purchased a site for the proposed new water works plant.

Carlisle, Ky.—Louisville concern has made proposition to install water works here.

Saint Matthews, Ky.—The St. Matthews Water Supply Co. has been incorporated with a capital stock of $3,000. The incorporators include Henry Bauer and Alex Staebler.

Uniontown, Ky.—E. R. Schiffley, C. L., Owensboro, Ky., is making plans and estimates for water works for this city.

Corinth, Miss.—City will issue $8,000 of bonds for making water works and sewerage improvements and extensions.

Fallon, Nev.—City Council wishes to get in touch with engineer to prepare plans, etc., for water works. The city is in the market for pipe and pump. C. L. Noble is City Clerk.

Mount Morris, N. Y.—J. F. Witmer, C. E.. Buffalo, N. Y., is preparing plans, etc., for water works for this village.

Greenspring, O.—Town is to vote June 23 on installing water works.

Put in Bay, O.—Village has voted to install water works.

Anadarko, Okla.—City has voted to issue $160,000 of bonds, $74,000 of which is for constructing additional water works.

Kiowa, Okla.—A $45,000 bond issue has been voted for installing water works.

Jellico, Tenn.—City proposes to install water works.

Humble, Tex.—Humble Ice, Light & Water Co. has been incorporated with a capital stock of $8,000. F. A. Peters, who has water works franchise, is one of the incorporators.

Denison, Tex.—City has voted $50,000 bond issue for water works improvements.

Ennis, Tex.—A $13,000 bond issue has been voted for water works.

TRADE NOTES.

The general offices of the Smokeless Fuel Co. and the Superior Portland Cement Co. are now located at 1503-13 Union Trust Bldg.. Cincinnati, O.

The Pelton Water Wheel Co. announces the removal of its executive and sales offices from 19th and Harrison Sts. to the Monadnock Bldg., 3rd and Market Sts., San Francisco, Cal.

After a continuous service of six years as General Manager of the Northampton Portland Cement Co., Mr. C. P. Jameson has severed his connection with the company, to take the General Managership of the Middle-West Portland Cement Co. at Iola, Kan., where he will have full supervision of the erection of a modern 3,000-bbl. per day plant, the selection and installation of machinery, operation of plant and disposing of its output.

In order to afford engineers, architects and others interested in foundation construction an opportunity of familiarizing themselves at first hand with its methods, the Raymond Concrete Pile Co. of New York and Chicago will give, at the coming Chicago cement show, working demonstrations of its systems of making and placing concrete piles. The Raymond system consists of placing a sheet steel shell in the soil by means of a collapsible steel core, withdrawing the core and thereupon filling the shell, previously subjected to a searching examination, with concrete. The entire operation will be shown at the Raymond Co.'s booth. A model driver will be employed in the placing of the shells.

The Standard Asphalt & Rubber Co. on Feb. 1 removed its general offices to suite 508-511 Home Insurance Bldg., 205 LaSalle St., Chicago, Ill.

The Leman Iron Works Co. has changed its corporate name to the Cleveland Iron Works Co. The company, which handles structural and ornamental iron and wire work, has its office and factory at 6824 Union Ave., Cleveland, O.

The Cement Products Exhibition Co. has appointed Joseph E. G. Ryan, Inter Ocean Bldg., Chicago, as press representative of the Second Annual Cement Show to be held Feb. 18-24 at the Coliseum, Chicago, Ill. The Cement Products Exhibition Co. suggests that the exhibitors send to Mr. Ryan copies of their catalogs, circulars, etc., and supply him with any other information that might prove good material for press notices. It will be well to accompany any printed matter of this sort with a letter, advising that it is being sent. L. L. Fest has been appointed Manager of Installation for the Second Annual Cement Show and will have direct charge of all matters pertaining to the installation of exhibits and the decoration of the Coliseum during the show.

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Editor ENGINEERING-CONTRACTING

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REFUSE INCINERATION PLANT.

Milwaukee, Wis., Jan. 28, 1909.

Sealed proposals will be received at this office until Wednesday, March 10, 1909, at 10:30 o'clock a. m., for constructing and erecting at the foot of Erie street in the Third Ward of the City of Milwaukee, a refuse incineration plant complete, with all appurtenances except the superstructure of the building and the chimney above the foundations, according to plans and specifications on file in this office and also on file at the office of Hering & Fuller, consulting engineers, 170 Broadway, New York City.

The bidder must examine the plans and specifications for the superstructure of the plant and for the chimney (to be let in a separate contract) and agree that these are sufficient for and will in no way interfere with the fulfillment of his own contract and guarantees.

He must make a personal examination of the site of the proposed work and must also make such investigations as are necessary to determine the combustible character of the refuse to be burned, as now collected in the City of Milwaukee.

Bidders must state prices as set forth and directed in Section 1 B. of the specifications, on specially printed blanks prepared for the purpose. Each bidder shall also prepare and submit with his proposal the drawings and statements enumerated in Section 1 B. of the specifications.

Work to be completed within one year from the date of the award of the contract, failing in which, the contractor shall pay to the City of Milwaukee, as liquidated damages, the sum of $500 per day for each and every day's delay in completing the contract.

Bonds to accompany bids required in the penal sum of $30,000, or in lieu thereof, the bidder may deposit with the Board of Public Works the sum of $15,000 in money or certified bank check. In case a bond is submitted, it must be signed by local bondsmen or by a surety company qualified to do business in the State of Wisconsin.

The blank form of the bond required, or the blank form for submitting money or check in lieu of the bond, will be furnished on application.

All moneys deposited will be returned to unsuccessful bidders on award of contract to and successful bidder when the contract is entered into.

The successful bidder will be required to enter into contract immediately after notification, with a bond for the performance of the work in a penal sum equal to the full amount of the bid for furnishing and erecting the plant.

Contractors desiring copies of the plans and specifications for their own use can secure the same from Hering & Fuller, consulting Engineers, 170 Broadway, New York City, on receipt of $15, as a guarantee for the safe return of said plans and specifications.

The Board of Public Works reserves the right to reject any or all bids.

CHARLES J. POETSCH,
J. P. SHERER,
L. A. JANSEN,
A. J. GRUNDMAN,
Commissioners of Public Works.
AUGUST M. GAWIN, Comptroller.

PIER WORK.—U. S. ENGINEER Office, 57 Park St., Grand Rapids, Mich., Jan. 18, 1909.—Sealed proposals for repair of south pier at Frankfort, Mich., will be received here until [illegible] p. m. Feb. 16, 1909, and then publicly opened. Information on application. M. B. Adams, Col., Engrs.

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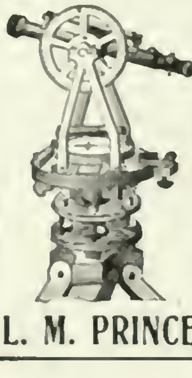

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CONCRETE VIADUCT.

Lynchburg, Va.

Sealed proposals, addressed to the Joint Council Committee on Streets and Sewers, and endorsed "Proposals for the Construction of a Reinforced Concrete Viaduct," will be received by the Council Committee on Streets and Sewers, at the City Engineer's Office, Lynchburg, Virginia, until 2:30 p. m., of Monday, the 15th day of February, 1909, and on that day at 3 p. m. will be publicly opened and read. The entire work is to be let in one contract.

A certified check for One Thousand Dollars ($1,000.00) shall accompany each bid, and a bond for Ten Thousand Dollars ($10,000.00) will be required for the faithful performance of the contract.

The approximate quantities are as follows:

1,600 cubic yards excavation,
220 tons steel bars,
3,700 cubic yards concrete,
1,040 square yards brick pavement.

Plans can be seen and specifications and forms of proposals and contracts obtained at the office of H. L. Shaner, Chief Engineer, Lynchburg, Virginia, upon making a deposit of Twenty-five Dollars ($25.00). This deposit will be given back to the bidder upon the return to the Engineer of the plans and specifications in good condition.

The committee reserves the right to reject any or all bids, should they deem it to be for the interest of the City of Lynchburg to do so.

H. L. SHANER, Chief Engineer.

WATER-WORKS.

Wichita, Kan.

Sealed proposals will be received at the office of the City Clerk until 7:30 o'clock p. m., March 15, 1909, for the construction of a water-works system for the City of Wichita, Kan. All work and material to be done and supplied according to plans and specifications on file in the office of the City Clerk. All work to be done under the direction and supervision of a special engineer to be employed by the city. The work will be paid for in cash or four and one-half per cent, twenty-year bonds, at the option of the city. Plans and specifications were prepared by Engineer Hiram Phillips of St. Louis, copy of which may be obtained by applying to the City Clerk upon deposit of twenty-five ($25.00) dollars.

The estimated cost of the above improvement is approximately $860,000. All bidders will be required to enclose certified check in the sum of $10,000, as a guarantee of good faith. The Mayor and Council reserve the right to reject any and all bids.

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PROPOSALS FOR A SEWER SYSTEM AND PUMPING PLANT.

East St. Louis, Ill., Jan. 14, 1909.

Proposals will be received by the Board of Local Improvements of the City of East St. Louis, Ill., until 12 o'clock noon, February 17, 1909, for the construction of a system of concrete and pipe sewers and a sewage pumping station as follows:

One pumping station building and appurtenances.

Five drainage and two sewage pumping engines to be vertical, single-acting gas engines, direct connected to horizontal shaft centrifugal pumps.

33,500 linear feet of sewers, varying in diameter from 3 to 10½ feet.

The work will be paid for in cash or bonds. Specifications, plans, form of proposal and other information may be obtained from the engineer of said city upon a deposit of $5.

W. J. CROCKEN, City Engineer.

CONCRETE SEWER.

Ashtabula, Ohio, Jan. 20, 1909.

Sealed bids will be received by the Board of Public Service of the City of Ashtabula, State of Ohio, at the office of said Board until 12 o'clock, noon, Tuesday, Feb. 16, 1909, for furnishing the necessary labor and materials for the improvement of West St. from Auger Ave. to Fred St., Fred St. from West St. to Haskell Ave., Haskell Ave. from Fred St. to Benefit St., Benefit St. from Haskell Ave. to Prospect St., Mills St. from Benefit St. to Hope St., Hope St. from Mills St. to Prospect St., by constructing a sewer therein, according to the plans and specifications on file in said office. The work includes approximately 1,372 lin. ft. 1′10″x2′9″ concrete sewer, 3,020 lin. ft. of 1′8″x2′6″ concrete sewer, 774 lin. ft. of 20″ sewer, 2,154 lin. ft. of 15″ sewer, 1,790 lin. ft. of 12″ sewer, 30 manholes, and all other labor, material, branches and appurtenances, as shown by the plans and specifications, or required by said improvement.

Bidders are required to use the printed forms furnished by the city, which can be had on application at the office of said Board, and are directed to observe the "Instructions to Bidders" therein contained.

The right is reserved to reject any and all bids.

By order of the Board of Public Service. A. J. RICHARDSON, Clerk.

DREDGING — U. S. ENGINEER OFfice, Milwaukee, Wis., Jan. 14, 1909.—Sealed proposals for building reinforced concrete caissons and pile pier, removing old pier and dredging at Milwaukee harbor, Wis., will be received here until 2 p. m., Feb. 12, 1909, and then publicly opened. Information on application. W. V. Judson, Maj., Engrs.

CONSTRUCTING QUARTERMASter's Office, Fort Des Moines, Iowa, January 20, 1909.—Sealed proposals, in triplicate, will be received here until 3 p. m., Standard time, February 10, 1909, and then opened, for constructing a steel highway bridge at Fort Des Moines, Iowa, target range. Information furnished on application. Plans and specifications will be sent to intending bidders upon receipt of request accompanied by certified check for $50.00, which will be refunded when the plans and specifications are returned. Envelopes containing proposals should be indorsed, "Proposals for Bridge," and addressed, Constructing Quartermaster, Fort Des Moines, Iowa.

COURT HOUSE.

Newton, Iowa

Sealed proposals will be received by the Board of Supervisors, Newton, Iowa, until 2 o'clock p. m. on the 18th day of February, 1909, for the erection and completion of a three-story Court House for Jasper County, plans and specifications for which are now on file at the office of the County Auditor. Plans and specifications can also be seen at the office of Proudfoot & Bird, architects, No. 625 Flynn Bldg., Des Moines, Iowa.

Bids will be received for the building complete, including heating, plumbing and electric work.

Certified check $5,000, bond 25 per cent of contract price.

The right is reserved to reject any or all bids.

FRANK SELLMAN, County Auditor.

FORT MYER, VA., January 11, 1909. Sealed proposals in triplicate will be received at the office of the Constructing Quartermaster, until 11 o'clock a. m., February 9, 1909, and then opened for the construction of a Band Stable at Fort Myer, Va. Certified check or Surety Company's guarantee for 10 per cent of the amount must accompany each bid. Plans and specifications will be furnished upon application accompanied by a deposit of $5.00 to insure safe return. The government reserves the right to reject any or all bids. Proposals should be indorsed "Proposals for Band Stables," and addressed to CAPTAIN B. B. HYER, Constructing Quartermaster.

KEY WEST, FLORIDA. Sealed proposals in duplicate will be received by the undersigned until 11 a. m., February 5, 1909, and then publicly opened for furnishing a condenser, filter, feed water heater, etc.; also for remodeling pumping and distilling plant at Key West Barracks, Fla. Plans and specifications on request. Proposals should be marked "Proposals for pumping plant" and addressed to CAPTAIN C. H. LANZA, Quartermaster, Key West, Florida.

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TUNNEL SEWER.

Niagara Falls, N. Y., Jan. [illegible], 1909.

Sealed proposals will be received by the Board of Public Works of the City of Niagara Falls, N. Y., at the City Building in said city, up to Tuesday, February 9, 1909, at [illegible] o'clock p. m., for the furnishing of materials and the construction of the following work:

No. [illegible]. A tunnel trunk sewer from the end of the present tunnel at [illegible] Street to Royal Avenue and in Royal Avenue and Royal Avenue extended to Union Street.

No. [illegible]. A sewer in Union Street from the end of the proposed tunnel to Buffalo Avenue.

All proposals must be made on blank forms, which together with other requirements, may be obtained in the office of the City Engineer, Convention Hall, where plans and specifications of the work may be seen.

The Board reserves the right to reject any and all bids and to waive all informalities.

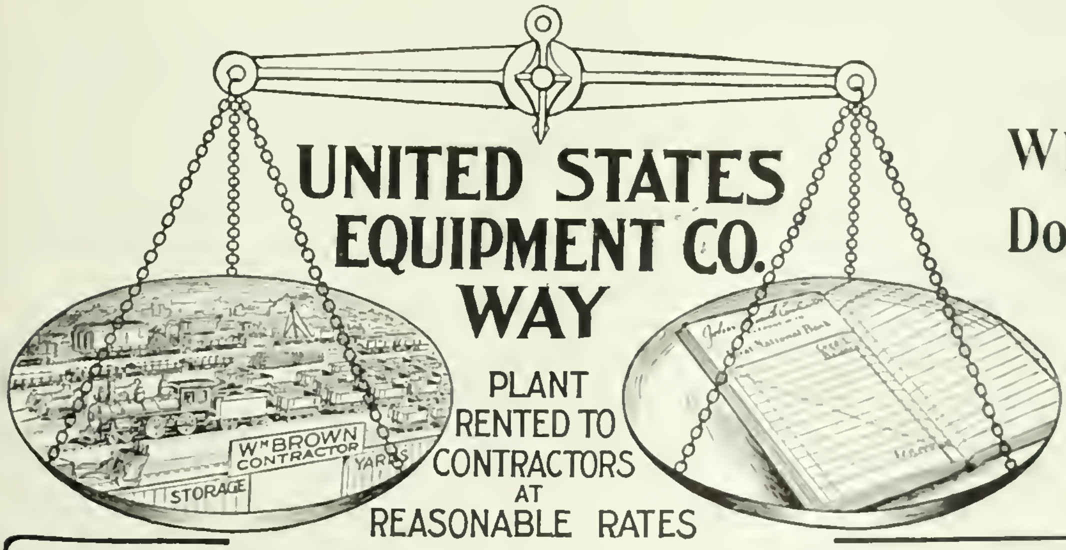
WALTER F. HORNE, City Clerk.
W. D. ROBBINS, City Engineer.

PUMPING ENGINE.

Phoenix, Ariz.

Sealed proposals will be received by the Superintendent of the Water Works of the city of Phoenix, Ariz., until 4 o'clock p. m. of Feb. 10, 1909, for one 3,000,000-gallon pumping engine. Bids must be accompanied by a certified check for 5 per cent of the amount of the bids, made payable to Frank Thomas, City Recorder. Specifications may be had upon application. Right to reject any and all bids reserved.

ROBT. A. CRAIG,
Supt. Water Works.



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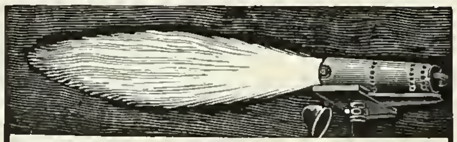

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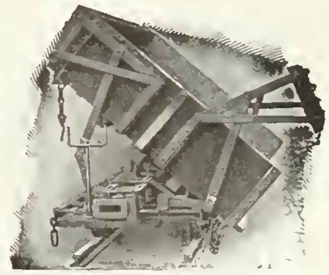

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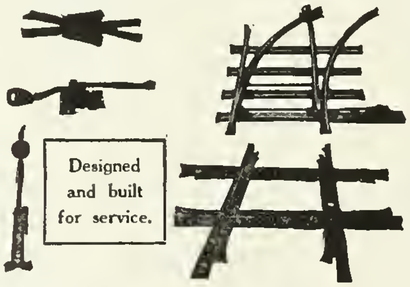

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PAVING.

Indianola, Iowa.

Sealed proposals will be received by the City Clerk, Indianola, Iowa, until 7 o'clock p. m., on the 8th day of February, 1909, for construction in said city of about 15,390 square yards of 3-inch creosoted wood block paving on a 5-inch concrete foundation and about 7,884 lineal feet of 6 by 20-inch concrete curb and about 450 yards of extra grading, according to plans and specifications now on file in City Clerk's office. Each bid must be accompanied by certified check for $1,500. For proposal blanks, etc., address

ARTHUR LEE, City Clerk.

PROPOSALS FOR CONSTRUCTION OF barracks and quarters, and plumbing and heating and electric wiring same. War Department, office of the Constructing Quartermaster, New London, Conn., November 28, 1908. Sealed proposals for constructing one double barrack, one single barrack, two field officers' quarters, one four-set officers' quarters, two lieutenants' quarters, three double non-commissioned officers' quarters, and one double firemen's quarters, at Fort Terry (Plum Island), New York, and two double barracks, two field officers' quarters, four lieutenants' quarters, two double non-commissioned officers' quarters, and two double firemen's quarters, at Fort H. G. Wright (Fisher's Island), New York, and for plumbing, electric wiring and installing heating plants in same will be received here until 10 a. m., Feb. 10, 1909, and then opened. Proposals are desired for brick construction of all buildings and for reinforced concrete construction on bidders' plans of barracks and non-commissioned officers' and firemen's quarters. Information furnished on application. Envelopes containing proposals should be endorsed: "Proposals for Public Buildings," and addressed: "R. M. Schofield, Major, Q. M., Constructing Quartermaster, New London, Conn."

COURT HOUSE.

Omaha, Neb.

Notice is hereby given that the Board of County Commissioners for the County of Douglas and State of Nebraska will receive bids for the construction of a Court House for Douglas County, according to the plans and specifications on file in the office of the County Clerk of said county. Bids will be addressed to D. M. Haverly, County Clerk, enclosed and sealed in properly endorsed envelopes, and filed with him not later than March 1, 1909, at 12 o'clock noon, at which time said bids will be opened.

Copies of the plans and specifications can be obtained from the undersigned or from the Architect, John Latenser, 632 Bee Building, Omaha upon application. A certified check for $50.00 must accompany all applications for plans, as a guarantee that bids will be submitted on the same, the check to be returned when the bids are opened.

All bids must be submitted on blank proposals, which will be furnished on application by the County Clerk, or John Latenser, Architect.

Samples of stone and granite upon which bids are based must accompany each bid.

Each bidder must submit with his proposal a certified check in a sum equal to 3 per cent of such proposal, the same to be drawn in favor of the Board of County Commissioners of Douglas County, Nebraska.

The Board of County Commissioners reserves the right to reject any and all bids.

D. M. HAVERLY,
County Clerk, Omaha, Neb.

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WANTED — SECOND - HAND STREET SPRINKLER, 6-inch tires. State present location. Address B. care of Engineering-Contracting, 721 Park Row Bldg., New York. 5-1t

POSITIONS WANTED — Two engineers, technical men, experts in highway, sewer and concrete construction, wish partner with plant. Address Box 85, Engineering-Contracting, 355 Dearborn St., Chicago.

WANTED—POSITION. Steam shovel engineer, 10 years' experience on all makes. First-class mechanic. Able to make any repairs. Address R. B., care of Engineering-Contracting, 721 Park Row Bldg., New York. 5-1t

WANTED—POSITION—Civil engineer who has been superintendent on sewer, concrete, highway and water works construction wishes position with engineer or contractor. Address Box 83, Engineering-Contracting, 355 Dearborn St., Chicago.

WANTED—POSITION as chief clerk or assistant superintendent. Young man 28 years old. Familiar with railway construction, mining and quarrying. Experience in the states, Canada and Newfoundland Can give best of references. Address A. L. Miller, Safe Harbor, Penna.

WANTED—POSITION as chemist or chemical engineer by graduate of leading technical school. Has had several years of practical experience and can fill responsible position. Best of references. Address Box "P. C.," care Engineering-Contracting, 721 Park Row Bldg., New York City. 17-tf

WANTED — POSITION with contractor. Have had six years' experience as engineer, chiefly on railway work. Prefer concrete work; location not important. If there is a vacancy on your staff let me hear from you. Address Box 77, care of Engineering-Contracting, 355 Dearborn St., Chicago.

WANTED—POSITION — Young man, 28, graduate in civil engineering from first-class college, desires position with engineering company. Four years' experience as instructor in civil engineering in two first-class colleges. Some practical experience at odd times. Address Box 86, care of Engineering-Contracting, 355 Dearborn St., Chicago.

WANTED—POSITION—Young man, for several years associated with large corporation as chief engineer's assistant, is open for engagement. Experienced in maintainance and construction of manufacturing plants. Location no object. Address Box 82, Engineering-Contracting, 355 Dearborn St., Chicago.

WANTED—POSITION—Graduate civil engineer, 1½ years' experience in general instrument work, desires position with engineer or contractor or firm engaged in construction work; location immaterial; moderate salary to start; A1 references. Address Box 90, care Engineering-Contracting, 355 Dearborn St., Chicago. 4-3t

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The Preparation of Expert Testimony on Costs of Construction.

In our issue of Jan. 13, 1909, we pointed out the necessity of being prepared to submit a complete analysis of every unit cost when testifying as an expert on costs of construction. We showed also that this involves the ability to present a tabulation of the plant required, its detailed first cost and cost of maintenance, and an itemized estimate of the number and classes of men in the crew required to operate the plant, together with their respective wages. Having thus itemized and tabulated the daily expense of operation, and having estimated the average number of units of work performed daily, a unit price is arrived at, upon which the expert witness can stand any cross-examination as to details without fear of contradicting himself. But if he goes upon the witness stand without such an analysis prepared in advance, he is likely to find himself drawn into the making of an ex tempore analysis which may be self-contradictory.

An expert witness is permitted to refresh his memory from written notes, but he ought to memorize the important items and the total unit costs, not only on account of the moral effect upon the court, but to enable him to meet any important inquiry on the instant. For example, a witness on concrete should certainly be able to give off-hand the amount of cement per cubic yard of 1:2:5 mixture.

An expert witness will often have his experience attacked, and at times the attempt is made to disqualify him for lack of experience. Disqualification seldom occurs unless a knowledge of specific prices or wages at a specific time and place is involved. In case an expert has no personal knowledge of such prices, he should be preceded by witnesses who have such knowledge. Then the expert can answer any hypothetical questions, assuming the prices upon which testimony has been given.

Prices of materials can be established by the introduction of printed market reports, if such are available. Rates of wages can be established from the evidence of labor agents. Hence the expert on costs need not have personal knowledge of prices and wages at any given time or place.

It is practically impossible to disqualify an expert on costs for lack of experience. It has been held by the courts that a student of medicine who had not yet received his degree could testify in a medical case, using only the knowledge gained under his professors and from the reading of books. (See Wait's "Engineering and Architectural Jurisprudence.")

Some lawyers seem to think that they can weaken the testimony of a cost expert if they can make him admit that he did not himself personally keep the time books and make the measurements of classes of work done under his direction and used as a basis for his estimates of cost. The expert witness need have no fear that his estimates are in the least weakened by any lack of personal attention to all such details. Following such a line of 'logic,' the expert would have to state that he had held both ends of a 100 ft. tape [illegible]. The expert need only show that he participated in the work, or supervised it, or checked it, and, by virtue of this participation, supervision or checking, was able to obtain a reasonably exact knowledge of facts.

An expert should never hesitate to go beyond his own personal records of cost in establishing his qualifications. He should cite the authorities that he has studied, and should establish in the mind of the court the fact that he has made a *study* of costs, using all available sources of information. While it is true that a book cannot itself be placed in evidence to substantiate the statements of an expert witness, still the witness can assert that his conclusions are in accord with the printed records of authorities on the subject. There are three distinct classes of scientific information in engineering books: First, records of physical or chemical tests; second, records of actual output or work done by men or machines; third, expressions of the author's opinion as to either of the above—the author's deductions.

It would seem to be clear that an author's conclusions should not be read to a court, for the author was not under oath when he wrote his conclusions and cannot be cross-examined as to the basis for his conclusions. On the other hand, it seems equally clear that printed records of physical tests on materials should be admissible, just as printed records of market prices are admissible. For the same reason records of the output of men or machines under stated conditions should be admissible.

In the "South Dakota rate case," before the supreme court of that state, an expert was permitted to cite records from a book giving the annual wear of rails under a given traffic.

When a book is to be used in this manner its authority must be first established by testimony. For further information on this phase of "expert testimony," the reader is referred to Wait's excellent chapter on the subject in his "Engineering and Architectural Jurisprudence."

Lawyers are frequently disposed to view with apprehension the introduction of testimony in their client's behalf by an engineering expert who has written an article or a book on the subject, fearing that, in the cross-examination, statements from the book or article will be read to contradict the expert's testimony. He is a poor author indeed who does not know his own writings better than any cross-examining attorney, and, if the expert has told the truth, any attempt to break down his testimony by selected quotations from his own works will simply serve to strengthen his evidence.

At times a cross-examining lawyer will attempt to make it appear that the expert who is an author is nothing but an author. This is apt to be done where the cross-

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examining attorney is "coached" by a so-called "practical man" who has an elevated contempt for any knowledge that has been reduced to writing. Usually, however, the man who is capable of collecting and arranging facts for publication, coupled with an ability to present the matter clearly and logically, is a man capable of convincing a court that his having spent the time to do so is no indication of his inexperience.

An expert who is perfectly reliable in his memory of unit costs is frequently apt to find his memory at fault as to total quantities and as to dates of events. A sharp cross-examining lawyer will seize upon any discrepancies of this kind to prove that the witness whose memory is at fault in one class of information is at fault in other classes. Such a lawyer will often carry the witness into great details as to the size of a structure built by him, time of building, quantities involved, contract prices, etc. Therefore an expert should refresh his memory from his records, and should enter all important matters in a note book to be used on the witness stand if necessary.

It will be seen from this brief outline that the commonest mistake that expert witnesses make is going on the stand unprepared. After visiting the site of the work about which the testimony is to be given, an expert should usually have at least two days in which to do nothing but study the plans and specifications and prepare his detailed estimate. Often it takes much longer. He should then be cross-examined severely by his own attorney to ascertain his preparedness and his knowledge.

Under cross-examination a witness is often asked questions the answer to which may involve considerable calculation as well as reference to records. In such cases the witness should make reply to the effect that he will need time in which to consider the matter and make the necessary calculations and that if allowed to retire for study of his records he will prepare the answer.

In the manner of delivering his testimony, whether in direct or in cross-examination, the expert should avoid an argumentative or biased attitude. He should support his conclusions with the strongest reasons, but he should be free to admit the existence of opposite views and not be dogmatic in his rejection of all ideas that conflict with his own. In a word, his attitude on the stand should be judicial rather than argumentative, or perhaps it would be better to say that his attitude should be professorial—the attitude of one who is expounding or teaching.

It is hard to preserve this attitude when one's views are attacked in cross-examination, but it can be done by any one whose temper is not too easily ruffled, and especially by one who knows his ground and is certain of the truth of the facts on which he has given testimony.

Concrete and Reinforced Concrete Section

Note:—This section is devoted to methods and cost of constructing concrete and reinforced concrete structures. It will cover the selection, testing and proportioning of concrete materials; laboratory tests of concrete; concrete mixing, transportation and placing; fabrication and placing of reinforcement, and form construction and erection. It will also contain articles on new and interesting developments in the design of reinforced concrete.

The Applicability and Economy of Concrete and Reinforced Concrete for Subway Construction.*

BY MR. CHARLES M. MILLS.†

(Broadly speaking, there are two general types of concrete construction for subways or underground urban passenger railways. The first type consists of bents consisting of side columns and roof beams spaced some 5 to 6 ft. apart, and filled between with concrete jack arch enclosing the steel I-beams which are generally used for both columns and roof girders. For 2, 3 or 4 track subways the bents consist of 1, 2 or 3 intermediate columns, besides the wall columns, and these intermediate columns may or may not be embedded in concrete. The second type of construction consists of reinforced concrete slab walls and either reinforced slab or slab and girder roofs. The intermediate supports for the roof for two or more tracks are, as in the first type, usually steel columns; there are no steel wall columns or roof girders. The first type of construction is the one which was used on all but a small portion of the original New York Rapid Transit Subway; a small part of the original line was of the second type of construction and practically all recent lines are also of this type. The second type of construction has been used nearly throughout for the Philadelphia Rapid Transit Subway. In the paper which we present below these two types of subway construction are compared on the basis of relative economy. As this is a comparison of distinct authority, Mr. Mills being the assistant engineer in charge of construction of the Philadelphia subway, and as subways are almost certain to be constructed in increasing numbers in the larger cities as time goes on, we have made copious extracts from Mr. Mills' remarks.—Editors.)

The adaptability and advantages of concrete, both plain and reinforced, to subways is so complete in most respects and is so well understood that only the salient features will be noticed, with general reference to economies.

Sidewall Construction.—For sidewalls, sustaining earth pressure, as well as vertical loads, reinforced concrete is especially advantageous since the thickness may be made but a fraction of that required for walls of brick or stone masonry. Thin sidewalls reduce the width of the trench to be excavated, an important and costly item of work in city streets. They are also usually necessary, since the available space under the beds of streets is frequently limited, either by existing structures, or by the necessary reservations for sewers or other underground structures, as municipal requirements increase.

Thin walls also may be built with vertical I-beams to resist the earth pressure, with vertical jack arches of concrete between them. The cost of such walls is slightly more than for those of reinforced concrete, the comparison of cost including many details. The I-beams are usually 12 or 15 ins. deep and spaced 5 to 6½ ft. apart on centers, and require some thickness of concrete back of them to cover the outer flanges. In addition, the protection of the beam from corrosion and the fact that the wall is pierced every 5 or 6 ft. by the beams renders waterproofing necessary. The placing of waterproofing, from the interior of the trench, requires a thin wall of brick or concrete outside of the beams. The total thickness of such composite walls, without concrete covering over the inner flanges of the beams, is usually from 21 to 24 ins. The inner flanges of the beams being uncovered require painting, which entails a maintenance charge. If the inner flanges of the beams are covered with concrete, the total thickness of the wall is increased, and this, with the details requisite efficiently to secure the concrete to the flanges, are additional items of expense. Little advantage, if any, in supporting traffic during construction is afforded by the beams, unless steel roof beams are used, since the timbering required prior to the erection of the beams may readily be designed to fulfill this purpose.

The sidewalls of reinforced concrete considered in the comparison of cost are taken 24 ins. thick, though 16 ins. would usually suffice to sustain all the stresses, the additional 8 ins. or 50 per cent being placed for practical considerations, partly construction details and partly to diminish liability of leakage. As the thickness of the wall is increased for the reasons stated, the quantity of main reinforcement is diminished with a resulting saving. No waterproofing is considered in the reinforced concrete sidewalls, since, with longitudinal reinforcement properly proportioned and distributed in the walls, and with the cement and concrete aggregates properly proportioned, made to a wet consistency and well placed in the forms, the use of waterproofing in reinforced concrete sidewalls is unnecessary under all heads of ground water liable to exist in ordinary subway construction, thus eliminating many troublesome details and simplifying the work.

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*Abstract of a paper presented to the National Association of Cement Users, Cleveland Convention, Jan. 13-16, 1909.

†Assistant Engineer, Philadelphia Rapid Transit Co., Philadelphia, Pa.

An advantage of reinforced concrete sidewalls with longitudinal reinforcement is that no expansion joints are required, and long stretches of wall may be built without cracks due to changes of temperature or to shrinkage, or to be more exact, with such a multiplicity of distributed minute cracks that they are harmless, and invisible except under the closest scrutiny. The longitudinal reinforcement may be varied to meet the various conditions, and to produce lesser or greater capacity to resist leakage, as desired.

The simplicity and superior water tightness of well designed reinforced concrete sidewalls makes them worth more than walls of beams and concrete jack arches, even though local conditions might show a slight saving in first cost of the latter.

It is probable that in most cases the first cost of reinforced concrete sidewalls will be a little less than that for the other type, but the difference will be a small percentage of the whole cost.

Roof Construction.—In the use of reinforced concrete for subways, both for sidewalls and roofs, slabs of uniform thickness have generally been employed, instead of an alteration of beams and slabs. The refinement of workmanship required in placing concentrated reinforcement in beams, with sheer rods, and the other details of beam and slab construction is injudicious from practical considerations in underground work. Such work is usually done in restricted space and with artificial light, so that good workmanship is secured only by the closest supervision and painstaking inspection. Though there be no desire to slight the work, the workmen are out of sight and simplicity of details is essential.

Under the conditions, the cost of plates of uniform thickness, considering the cost of forms and their handling and of the reinforcement and its placing, is less than that for an alteration of beams and slabs, and compensate for the additional material required.

It is probable that with the advance being made in the production of assembled reinforcement handled in units, construction of roofs with an alteration of beams and slabs may be found advantageous, since economies may result to compensate for the additional expense now entailed by such design, and methods devised to secure good work under the difficult conditions.

Since it is desirable to make the depth from the street surface to the passenger platform as little as practicable, and the distance from the top of the roof to the street surface is usually determined by the space necessary for the water and gas mains, electrical conduits and other underground structures, the arched roof is often objectionable owing to the increased depth of the structure due to the rise of the arch. Flat roofs have been mostly employed with a moderate slope for drainage.

Flat roofs are built of cross beams or girders with jack arches of concrete, and also of reinforced concrete alone. Due to the considerations previously described, the reinforced concrete roofs have been of plates of uniform thickness.

Since the drainage grades on flat roofs are slight, and accidental leaks in roofs are more objectionable than when they occur in sidewalls water-proofing is always used.

In comparison of the costs of roofs the item of water-proofing is common to all styles of flat roofs and reduces the elements of difference to the other features of the designs.

The execution of permanent and water-tight roofs with beams and concrete jack arches involves many details requiring care, and it may be said that greater simplicity and superior permanent results are obtainable with reinforced concrete alone.

With beams and jack arches, it is necessary to introduce reinforcement to prevent cracking due to shrinkage and temperature stresses, particularly immediately over the beams where the concrete is liable to crack and cause leaks, water tending to flow along the webs and flanges. Reinforced concrete in such places is superior to any other available material in securing enduring and water-tight work. Another source of leakage where beams are used is the thinness of the concrete back of the ends of the beams where they rest on the sidewalls. Such roofs require careful and efficient waterproofing, and but little dependence should be placed on the waterproofing to bridge over or seal cracks in the concrete.

The cost of flat roof with transverse beams and jack arches of concrete is found to be cheaper than reinforced concrete roofs with plates of uniform thickness. This is partly due to a lack of economy in using plates of uniform thickness and partly to construction details.

From the foregoing it appears that the first cost of a two-track subway with reinforced concrete sidewalls and a roof with beams and concrete jack arches may usually be found less than that of a structure entirely of reinforced concrete, but such inference should be considered with caution for the reasons previously indicated. The difference in cost, if in favor of the beams and concrete jack arches, would be but a small percentage of the entire expense. On the other hand, the permanent advantages of an entire reinforced concrete structure are markedly great, and maintenance charges inseparable from composite structures of structural steel and concrete are eliminated.

As to the cost of various types of structures, it is possible that with space for masonry sidewalls in a subway for two tracks, and with the roof in one span and with favorable conditions, economies might result, so that the cost of such a structure as a whole would not exceed that of one with thin walls of reinforced concrete and might be less.

Reinforced concrete permits the use of arched cross sections in cases where plain concrete or brick masonry would involve uncertain stability under the action of concentrated loads, particularly with the probability of the excavation of trenches parallel to and alongside of the structure. Consideration of the latter contingency is imperative, due to the growing demand for underground service for public utilities, and the growth of municipal improvements, by which increasing space is required beneath the streets.

In addition to the sidewalls and roofs of subways, the concrete plain or reinforced, is well suited to the construction of floors, inverts, platforms, stairways and other parts of underground railways. By using the precautions to exclude water by proportioning the constituent and reinforcement concrete may be used for inverts or floors to better advantage than any other known material. This statement applies also to pumps, pumping chambers, underground passages and other deep construction, good results being attainable with less expense than with any other material and with much less difficulty.

An interesting demonstration of the advantages of reinforced concrete occurred in the building of the Market Street subway in Philadelphia, between the City Hall and the Schuylkill River, at 21st St. A large water main on the north side of the street parted at the junction with a main on 21st St., the rush of water excavating a large hole in the street and carrying the debris into the uncompleted subway. A small egg shaped reinforced concrete sewer built as part of the drainage diversion caused by the subway construction, sustained itself as a bridge with a clear span a little over 10 ft. wide and not only carried its own weight, but also a quantity of earth, paving stones and other debris. No fractures were found in the sewer, only some small cracks, and the leakage from the sewer, which had been in service for some time, amounted only to intermittent drops. The washout was back-filled and the street repaved without the necessity for any repairs to the sewer. The incident confirmed the judgment exercised in the beginning of the work, to build the new sewers parallel to the subway of reinforced concrete.

The Economies of Graded Concrete.*

BY E. M. PERDUE.

The first essential of good concrete is good Portland cement. Good Portland cement does not mean a cement of any particular make, manufacture or brand, but a Portland cement that has passed the standard tests prescribed by the American Society of Civil Engineers. Concerning any cement, no constructing engineer has a right to an opinion as to quality or excellence, unless he has tested it himself, or has had it tested by some one competent to do such work.

The second essential of a good concrete is a graded aggregate. This is composed of graded broken stone, or graded gravel, or a graded mixture of both. This grading must be based upon the rules and formulas of maximum density. The voids between the largest broken stone must be filled by the largest possible pieces and the resulting voids in like manner by pieces of increasing fineness. The proportions required are worked out by sifting and weighing the crushed stone. The curves of these siftings are platted on a system of abscissas and ordinates and the curves of the various kinds of stone combined so as to plat a parabola in the positive segment. Since the maximum size of stone is 100 per cent, the parabola must be platted to the formula $10\sqrt{x}$, when x equals the percentage corresponding to the part, any size of stone is of the maximum size in the mix.

Concrete mixed according to formulas of maximum density, will be smooth because the voids will be filled; for the same reason it will be impervious and strong.

For like purposes, concrete, when made of scientifically graded stone, can be made one or two parts leaner in cement than concrete made of ungraded stone. The approximate percentage of cement in the various mixtures is here given:

Mix.	Percentage of Cement.
1—2—4	14.28
1—2—5	12.5
1—3—4	12.5
1—3—5	11.1
1—3—6	10.0
1—3—7	9.0
1—3—8	8.3

From these figures it can readily be seen that the increase of the crushed stone by one or two parts means, in the aggregate, a saving of from 10 to 20 per cent of the Portland cement. On a contract requiring only 10,000 bbls. of cement, if were possible to save 1,000 bbls.; 1,000 bbls. at $1.25 are worth $1,250, an item worth saving. On a contract requiring the use of 100,000 bbls., the minimum saving would be 10,000 bbls., worth $12,500.

The same machinery and the same set of men in the same time at the same expense can lay 50 per cent. more graded than ungraded concrete and do it easier, This materially lessens the expense, shortens the time of completion of the contract and correspondingly increases the profits of the contractor.

Of the uses of concrete in this part of the United States, by far the largest proportion is laid at the base of street paving. With stone advantageously piled at street intersections, teams hauling sand, and steel dump carts delivering the concrete to the street, the daily expense may be estimated as follows:

1 Foreman	$ 4.00
1 Engineer	3.00
20 Men on stone at $2.00	40.00
2 Men on sand at $2.00	4.00
3 Men on cement at $2.00	6.00
3 Men on machine at $2.00	6.00
4 Teams on sand at $4.00	16.00
2 Carts, horse and man	6.00
3 Graders at $2.00	6.00
1 Tamper	2.00
1 Water boy	1.00
1 Timekeeper	1.00
	$95.00

If at this expense of $95, 1,000 sq. yds. of 6 in. concrete be laid, it is laid at an expense of 9½ cts. per sq. yd. If the amount be increased to 1,500 yards at the same expense, it is laid at a cost of 6⅓ cts. per sq. yd. In a contract of 100,000 yards the saving is the difference between $9,500 and $6,333.33, or $3,166.66.

It will be objected that this is all theory. Now for a recent practical example. The writer was employed in 1907-8 by the city of Enid, Oklahoma, where five miles of streets were paved with asphalt with a 6-in. concrete base. Cement was high and no stone within a radius of 100 miles or within 1,500 ft. deep. Stone of five different grades was procured from Carthage and Carterville, Mo., Galena, Kan., and Uncas, Okla. The amount and transportation of each kind were uncertain. The stone most readily procured had a maximum of 3 ins. and a minimum of about 1 in. The contractor had the option of using natural cement. Using cement, sand and the coarse stone, a Foote continuous mixer driven by a steam engine, and the most approved methods of handling stone and concrete, 1,000 sq. yds. were laid in a 10 hour day. After grading so that any stone on hand could be used, the same gang of men with the same machinery, laid 1,500 ft. of concrete in a 10 hour day and did it easier than they formerly laid 1,000 sq. yds. of the coarse stone. Cement was saved so that for the same price the contractor laid Portland cement instead of natural cement. The maximum output for a day attained nearly 1,700 yds.

The cement for this contract was of various brands, all the Iolas, Western States, Indian Head and Atlas. It was tested. The resulting concrete was dense and very strong. It was not tested out in beams as in reinforced work. However, it had a practical test which was very satisfactory both to the engineer and the contractor. A block of concrete had been down scarce a week next to a railroad yard. A freight car loaded with Portland cement jumped a switch, ran down a three foot embankment and across the concrete street. This car was pulled back across the street. It did not as much as crack this concrete.

A second larger contract was taken by the same company, the percentage of cement was reduced and the best five miles of pavement in the southwest finished, to the satisfaction of the city, the property owners and the contractor.

The scientific grading of concrete is the important part of concrete construction.

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*Condensed from the "Cement Record" for January, 1909.

Cost of Metal Forms For Concrete Building Work.

In Engineering-Contracting for Sept. 16, 1908, we described a system of metal column and floor forms for concrete building work that had been worked out by Mr. W. L. Caldwell of Canton, Ohio. In a paper read at the recent annual convention of the National Cement Users' Association Mr. Caldwell gives some estimates of the cost of these forms which are of interest. These costs are based on a 16-in. square column, with a girder beam 8 ins. wide and 18 ins. deep below floor slab, and with the lateral beams 6 ins. wide and 12 ins. deep, and floor slab 4 ins. thick.

For a structure of this character, Mr. Caldwell recommends the use of 10-gage material for the angles at the four corners of the columns, 14-gage for the lining of the columns, 14-gage for the girder boxes, 16-gage for the lateral beam boxes and 18-gage material for the channel boards forming the intercolumn area for carrying the floor slab, with all necessary reinforcing angles, bolts, etc., to set up the work complete ready for receiving the concrete.

The costs are as follows:

Column centering per lineal foot	$1.75
Girder centering per lineal foot	1.00
Lateral beam centering per lineal foot	0.50
Floor area per square foot	0.13½
Adjustable girder and beam box posts per lin. ft.	0.05

Throwing the cost of all of these items against the floor area, the average is about 45 cts. per sq. ft.

This price is arrived at by taking a building 50 x 100 ft. with 28 columns and 18 bays or intermediate column spaces, each space or bay containing 237 sq. ft., in round numbers, each bay divided by two intermediate cross beams, or three spans to each bay. These figures will vary somewhat with the different types of buildings but will give, it is stated, a fair idea of the average cost.

Under ordinary conditions these centers can be erected at a cost of approximately 1¾ cts. per sq. ft. for labor.

The Resilience of Reinforced Concrete.*

BY E. J. M'CAUSTLAND.

It is a familiar experience to those who have conducted tests on reinforced concrete beams, and on beams without reinforcement, to find that even under comparatively light loads a permanent deformation takes place in the specimen and that this deformation increases with the loading, although not necessarily nor generally in direct proportion thereto.

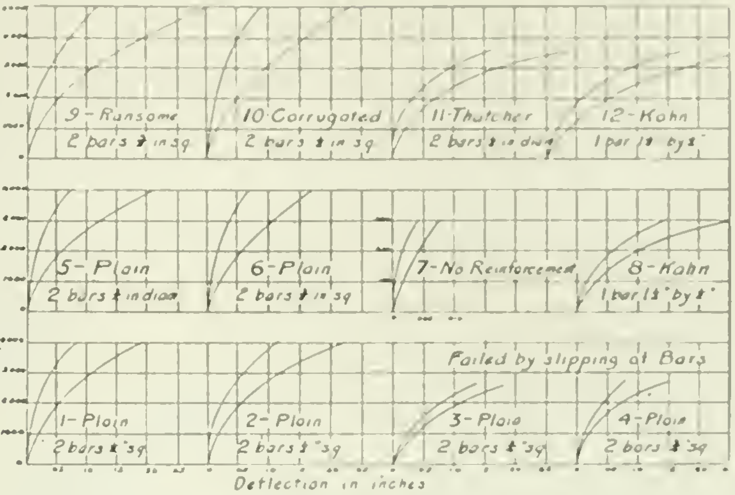
In much of the current experimental work of testing beams of which we find record in the technical press, the measurement of these deformations is omitted, although in a few instances we find them reported.

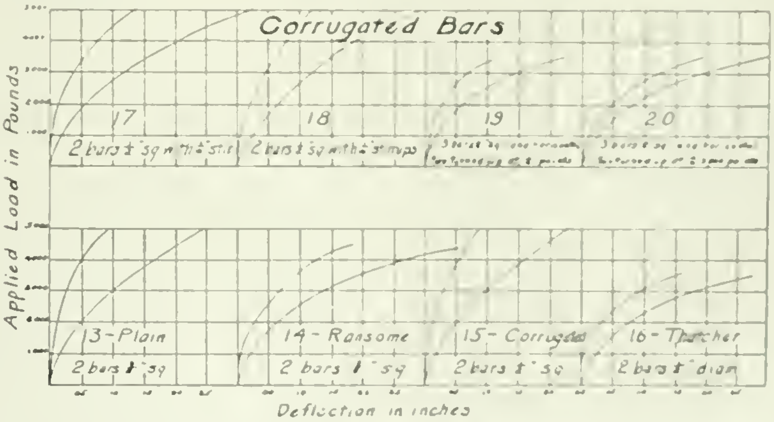
In tests of columns and beams, if the measurements of shortenings and deflections are taken while the load is on and again when the load is released, and this routine of measurements repeated for each increment of load, information may be obtained regarding the resilience of the material under investigation.

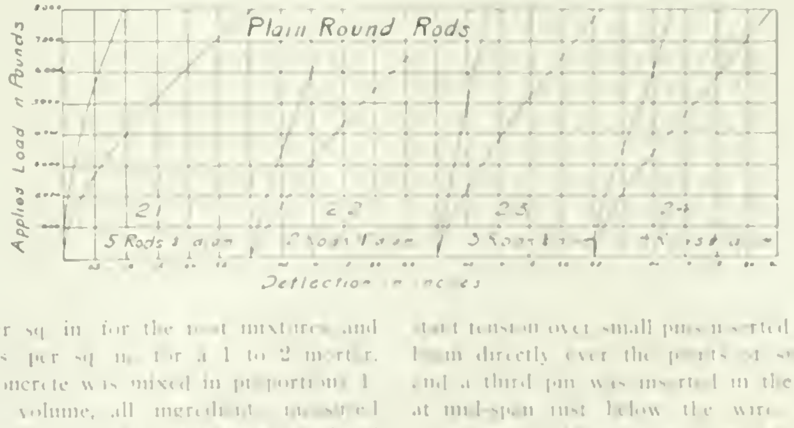
The writer offers here some diagrams which show graphically the results of some tests of his own, and desires to call attention to a few points that seem to be emphasized by a careful comparison of these curves.

In the fabrication and testing of the specimens to secure the data from which the accompanying curves are plotted, two entirely different conditions prevailed, both in regard to the class of material used and the size and span of the beams. The specimens tested fall into two classes and these will be designated respectively as Series "A" and Series "B." Beams numbered 1 to 20 inclusive constitute Series "A," and beams numbered 21 to 24 inclusive constitute Series "B."

Description of Materials Used.—The stone for Series "A" was limestone, run of crusher, with maximum size passing a one-inch ring, containing a large proportion of dust and weighing eighty-five pounds per cubic foot. The sand was medium bank sand containing about four per cent of clay. The cement was Portland, bought in the open market and was of the well known Alpha brand, tests of which at 30 days gave an average tensile strength of 740 lbs. per sq. in., neat, and 410 lbs. per sq. in. in a 1 to 3 mortar. The concrete was mixed quite dry in proportions 1-3-8 by volume and left in storage at a temperature of 75° F without sprinkling. When the 6 in. cubes were tested for compression at 30 days they gave the very low ultimate stress of 980 lbs. per sq. in. This low stress was no doubt due to the three factors of lean mixture, small percentage of water used in fabrication and high temperature of storage. The beams were made 6 x 8 ins. in section and were tested on a span of 6 ft. The center of the reinforcing rods was placed in all cases 6½ in. below the top of the beams. Tests of all beams were made at the age of 30 days.







The stone for Series "B" was limestone, screened to pass a 1¼ in. round opening and held on a screen with opening ½ in. in diameter. This stone weighed 88 lbs. per cu. ft. when measured loose, and had about 48 per cent of voids. Sand was taken from a bank pit, was rather fine and contained about 1 per cent of clay. It had 31 per cent of voids and weighed, loose, 100 lbs. per cu. ft. The cement was of the mixed brands furnished by the Joint Committee on Concrete and Reinforced Concrete, and gave a tensile strength at 60 days of 705 lbs. per sq. in. for the neat mixture and 141 lbs. per sq. in. for a 1 to 2 mortar. The concrete was mixed in proportions 1-2-4 by volume, all ingredients measured loose. The average crushing strength of this concrete at 60 days as determined by tests on 4 10.6 in. cubes was 1670 lbs. per sq. in. The reinforcing rods, of mild steel, had an ultimate strength of 61,680 lbs. per sq. in. and an elastic limit of 40,000 lbs. per sq. in. The beams were 8 x 11 in. in section, and were tested on a span of 12 ft. The center of the reinforcement was placed in all cases at 10 in. from the top of the beam. Tests were made at the age of 60 days.

In both series the tests were made by applying the load at the one third points of the span, and the center deflections were measured from a fine wire stretched along the side of the beam and opposite its mid depth. This wire was stretched at constant tension over small pins inserted in the beam directly over the points of support, and a third pin was inserted in the beam at mid-span just below the wire. The movement of this pin away from the wire when the beam was under load was taken as the deflection. This movement was measured by a Brown and Sharpe micrometer reading directly to 1/1,000 in., and by estimation to 1/10,000 in., contact of the micrometer being determined by the ringing of an electric bell.

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*Reprinted from the "Cornell Civil Engineer."

In testing Series "A" the load increment was 250 lbs. and in Series "B" it was 1,000 lbs. Loads were released to zero after each application and micrometer readings taken to determine the permanent deflection or "set" of the specimen.

In all cases, except beams 19 and 20, the reinforcing bars were placed parallel with the edge of the beam. In these exceptions the reinforcement consisted of three corrugated bars, the middle one placed parallel to the edges of the beam and the other two turned up at the quarter points of the span so that the ends of the bars reached to a point within 1 in. of the top surface of the beam. Beams numbered 17 and 18 had stirrups formed like an inverted U, placed vertically every 6 ins. along the beam except for the middle one-third of the span. These stirrups were of ¼-in. round rods and the lower ends were twisted around the horizontal reinforcing bars, but this twisting did not form a rigid attachment.

In examining these curves it is seen that they fall into two general classes determined apparently by the nature of the reinforcement,—whether plain or deformed bars. One cannot fail to be impressed by the marked difference in the amount of permanent set which takes place under deflection in beams reinforced with these two types of reinforcement.

In the curve plotted for Beam No. 7 (note the exaggerated scales), we have shown the typical relation between the deflection and the permanent set of a beam that is without reinforcement, and in the curve for No. 6 we have the same relation in typical form for all beams with plain undeformed bar reinforcement. It may be said that, with the exception of Beams Nos. 3 and 4, the curves for the beams with plain reinforcement differ but little in general character from the curves drawn for beams without reinforcement. In other words, a smooth rod or bar when used as reinforcement in a concrete beam does not act to modify in any marked degree the resilience of the beam as a whole; meaning by resilence, in this connection, the ability of the specimen to reproduce energy put into it. The apparent exceptions to this general statement, shown in curves Nos. 3 and 4, are explained when we give due consideration to the manner of failure of these beams. Failure was induced by the slipping of the rods in the unusually lean mixture and the resilience of the concrete was not sufficient to overcome the friction of the rods in the mass and force the beam to resume its original form.

The general character of the curves plotted for the beams reinforced with deformed bars is quite different from that of the curves for the beams with smooth reinforcements. Perhaps the most striking difference is exhibited in the case shown in curves Nos. 8, 11, 12 and 16, where the deflections are excessive and the recovery under released load is very small. It seems clear that the effect of certain types of reinforcement in beams is to allow excessive deflection under loading, and to act in a manner to prevent the recovery of the specimen when the load is removed.

It is not believed that these tests are numerous enough or that they are sufficiently concordant in results to warrant general conclusions, but it is believed that they clearly point the way to an important field for investigation in reinforced concrete work.

In what manner is the relative stiffness of beams, of approximately equal strength, affected by the type of reinforcement used?

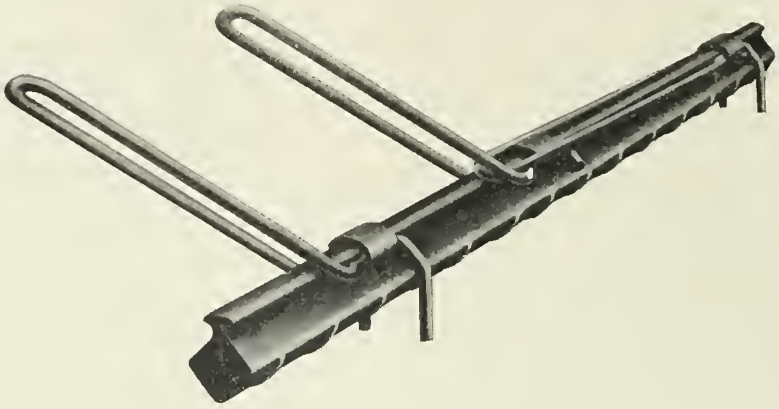
If deflections take place in reinforced concrete beams under repeated and increasing loads or shocks, what is the effect of the type of reinforcement in measuring its ability to absorb these loads and shocks without permanent injury?

No doubt a carefully planned series of tests, carried out in detail, could furnish information on these points that would be of much value to designers in reinforced concrete.

Travelers on the Hedjaz Ry. in Turkey, which is to connect Damascus with Mecca, can pray as they go. According to Ottoman newspapers the trains will contain carriages fitted up as a mosque, where pilgrims will be able to perform their devotions during the journey to the sacred cities. Externally the praying carriage is only distinguished from the other carriages by a minaret 6½ ft. high. The interior is luxuriously fitted. The floor is covered with the richest of Persian carpets, while around the sides are verses from the Koran appropriate to the pilgrimage in letters of gold. A chart indicates the direction of Mecca at one end, and at the other are placed four vessels for holding water.

The Herringbone Trussed Bar.

The accompanying engraving shows a trussed reinforcing bar, or more accurately, a reinforcing bar with attached stirrups which possesses several features of value. The bar proper is rolled to special section and has lugs or ribs to give it mechanical bond. The stirrups are looped around bars clamped to the neck of the main bar as shown. This cut shows two of the stirrups bent up to the positions they occupy when in the work, and a third stirrup bent down flat on the main bar, which is the position of all the stirrups when the bar is being shipped. This flat position of the stirrups is a decided advantage in shipping and handling the bars. A second feature is that the free ends of certain of the stirrups are extended and bent down to form chairs by which the main bar is spaced away from the bottom boards of the forms so that the pouring will completely embed the bar. A third and particular feature of this bar is that the stirrups may be of any desired length irrespective of the main bar and may also be placed with any distance of spacing that the conditions demand. This bar has recently been put on the market under the name of the Herringbone Trussed Bar by the General Fireproofing Co., Youngstown, Ohio.



Herringbone Trussed Bar.

Experiments under the direction of Dr. H. T. Barnes, Professor Physics at McGill University, are under way to determine the possibility of winter navigation on at least a portion of the River St. Lawrence. The Canadian department of marine and fisheries will render material aid in conducting the investigations, such as defraying the expense of assistants, providing necessary scientific instruments, and furnishing accommodations on board government ice breakers. Records will be kept of temperatures of water and atmosphere, strength of ice, observations of local conditions, etc., and all other important factors which will be of assistance in arriving at an ultimate conclusion. One of the government ice breakers, the Montcalm, is now operating in the river in the vicinity of Seven Islands.

Earth and Rock Section

Note: This Section is devoted to methods and costs of excavating earth and rock and building embankments. It will cover the grading of roads and railroads, diking and canal work, dredging, building reservoirs and earth dams, sewer and water pipe trenching, quarrying, etc.

A High Cost of Earth Excavation with Dump Carts.

It is sometimes as valuable to know how not to do a thing as it is to know how to do it. This is especially so in construction work and in earth excavation. The following example, showing a high cost of earth excavation done with dump carts, is given to illustrate how not to do such work.

The excavation was made on the grade of a railroad in taking out several small cuts, there being 1,743 cu. yds. in the combined cuts. The material was a sandy clay, and the average haul was 500 ft. The work was done in the fall of the year with good weather conditions, there being but one rainy day during the time. With this class of material, without any stones in it and the depth of cutting and length of haul, the excavation was ideal wheel scraper work, but the work being done by company forces and the railroad company not owning any scrapers, it was decided to hire carts and do the work with them.

The earth was loosened by a plow, but the plowing was not done well enough, so that some of the men had to pick it. Naturally using a plow prevented the material being worked to a breast and the carts were hauled over the loosened material. This made the hauling hard for the horses and prevented full loads from being carried and also compacted the loosened material somewhat. An average of 17 carts were worked with 58 men and 3 foreman. A single foreman being in charge of 29 men in this class of work with men and carts scattered over a cut was bound to give poor work. The men clustered around a cart and loaded it as they would a wagon, and in using short handled shovels, the amount of work that could be done in a day was reduced over the number of cubic yards that could be loaded into a cart at the end with the tail gate out. With such large number of men it was also possible for the men to loaf. If carts were to be used they should have been loaded from the rear in the regular way, and some system of shoveling up the plowed material should have been adopted so that the carts would have been well loaded and the foreman could have made the men do good work. Or else the material should have been worked to a breast, and the carts loaded two at a time and sent to the dump with one driver. In the work done one driver was assigned to each cart. Four horses and two men were used on the plow.

A ten hour day was worked and the following wages were paid:

Foreman	$2.50
Laborers	1.50
Carts and driver	3.00
Plow team	9.00

The cost of the work was as follows:

Foreman	$ 52.50
Laborers	610.50
Cart work	357.00
Plowing	36.00
Extra work	11.50
Total	$1,067.50

This gives a cost per cubic yard of the following:

Foreman	$0.030
Plowing	0.020
Laborers	0.350
Hauling	0.205
Extra work	0.005
Total	$0.610

The extra work consisted of digging some ditches after a rain to drain off the water, two foremen and 12 men being engaged on this for half a day.

The very high cost and poor work is shown by the fact that a man only shoveled 4¼ cu. yds. of a material, that could be classed as average earth, in 10 hrs. A man should have shoveled, after the material was loosened, 14 cu. yds. in 10 hrs.

In Gillette's "Earth Work and Its Cost" on page 39 a rule is given for obtaining the cost of excavating earth by loosening it with a plow, shoveling it by hand into carts, and hauling it. According to this rule the work should have cost 30 cts. per cu. yd., not including foreman, a high but not excessive cost considering the wages paid. The cost of 61 cts. per cu. yd. is accordingly about twice as much as it should have been.

If scrapers had been used, as the work, as previously stated, was well adapted to them, the cost per cubic yard should not have exceeded 25 cts., which would have effected a great saving. The lesson to be learned from this work is very plain.

The U. S. Civil Service Commission, Washington, D. C., will hold an examination on March 17-18, 1909 at various places throughout the country, to secure eligibles from which to make certification to fill a vacancy in the position of mechanical and electrical engineer, $1,800 per annum, Quartermaster's Department at Large, Fort Bayard, N. M., and vacancies requiring similar qualifications as they may occur in any branch of the service.

Comments on the Use of Wagons in Transporting Earth.

(Continued from page [illegible].)

In loading large wagons by hand, the height of the wagon body is a great disadvantage. The number of foot pounds of work done by a man per day is less in a vertical distance than in a horizontal distance. An inch or two additional height to the side of a wagon tends to decrease the amount of earth that a man can load per day. The bottom of an average dump cart is about 31 ins. high, varying an inch or more either way in different makes of carts. At this height, in average earth, well loosened, a man with a short handled shovel will load 14 cu. yds. in 10 hrs., or at the rate of 1.4 cu. yds. per hr. To decrease this height means to increase the amount of earth handled per man day, but as a man can load dirt into a cart without straightening up his back there is not the same proportion of increase in the yardage handled, as there is a decrease when the height is greater than about 3 ft.

The height of the top of the sides of the ordinary dump wagon, of 1 cu. yd. or 1½ cu. yd. capacity, is from 4 ft. 6 ins. to 5 ft. A man at this height will shovel with a short handled shovel about 13 cu. yds. in 10 hrs. Over this height to increase the height of the sides of the wagon by 6 ins. means to decrease the amount shoveled per man day by about 10 per cent. This is the experience of the writer and he is corroborated in this by a number of contractors who have kept careful records. The reason for this is that in order to cast the earth into the wagon the man must first straighten up his back, after he has filled his shovel, and then by another motion he casts his load into the wagon.

To load wagons with men and shovels from 4 to 10 men are placed around a wagon, and they cast the earth over the sides and end. To load carts, seldom more than 4 men are used to the cart and they are behind the cart, and cast the dirt into the open end of the cart. In this case the men are crowded somewhat together and each man has but a few feet of space in which to operate his shovel. For cart work, especially in cramped quarters, short handled shovels are a necessity. However, in loading wagons the men have a much greater space in which to work, and as the height is a foot or two greater there is no longer any excuse for using short handled shovels. With long handled shovels a greater yardage will be loaded. With long handled shovels the writer, in average earth or good clay, has had men to load into wagons between 14 and 15 cu. yds. in 10 hours, and to increase the height of the wagon 6 ins. meant only to decrease the amount loaded per man day by about 7 per cent, until the height exceeded 8 ft. The writer has never used wagons with sides that exceeded 8 ft. in height.

For these reasons we recommend that

wagons used in hauling earth and are loaded by hand should be built low, and that, except under a few circumstances, long handled shovels should be used for loading. Too much stress cannot be laid on this nor can contractors' and engineers' attention be called to this matter too often, as in all of our towns and cities where wagons are loaded by hand continually, these mistakes are made every day. In New York City, where a great many high dump wagons are used, short handled shovels are supplied to the men. Even with long-handled shovels, wherever possible the low wagon should be used, even if it is necessary to keep among the contractor's plant the two kinds of wagons, as the difference in the amount of material that can thus be handled in a season's work would in many cases pay for the extra lot of wagons. Even if the cost of the wagon would not be made up in a season, more than the interest and depreciation on the extra plant bought can be earned.

Another important consideration in wagon work is to keep the wagon on the road as much as possible. An ordinary price paid for a hired team and wagon, at, present, is $5 per day. With a 10-hr. day this means a cost of nearly 1 ct. per minute, while with an 8-hr. day it is slightly over 1 ct. With 10 or 12 wagons only being used a delay of a minute or two quickly runs into a money loss. Thus all the men that can be conveniently worked around a wagon should be employed. With plenty of room 10 men can ordinarily be worked around a wagon. Four men on each side and two at the end. With less space 8 men can be used. This shows the folly of loading a wagon at the end only, as a cart is loaded, with 4 men, or with 6 men. With 4 men at the end, the wagon is in the cut at least twice as long as it should be. With 6 men working at the end of the wagon, 2 of them must take several steps to cast their shovelful into the wagon, and men should never be allowed to walk as they are shoveling. For these reasons wagons should not be loaded from a breast.

When wagons are loaded from a breast the earth is generally loosened by picks. A cheaper way is to use a plow. In plowing, a turning plow should be used and if possible the ground should be plowed twice, as in most heavy materials plows will not loosen the earth sufficiently to allow of easy shoveling, and if a second plowing is not done pickers will have to be used. Even this second plowing will, as a rule, be found cheaper than using a few pickers. When plowing and then loading on the shovels, the whole area of the excavation will be taken down at one time.

In narrow cuts or lots this is not always practical, and in such place it is often necessary to do some picking, but the majority of the material can still be plowed. One way of taking out material with wagons that the writer has used is illustrated in Fig. 1. A cut, or a series of cuts, are made as shown. The material in these narrow cuts is plowed and shoveled into wagons, and when they are taken to a depth of 6 to 7 ft. the material between the cuts is excavated. With a slope of 2:1 or even 1½:1 the earth can be plowed. The shovelers are now able to stand on the sides of the slopes on a level with the top of the wagons or above them and with long-handled shovels can handle a larger yardage with less exertion. As some of the top material is worked off, the bottom of the narrow cut is deepened until the bottom of the excavation is reached, then the rest of the materials is worked out. With this method a large per cent of the material to be excavated is loaded cheaper than by the ordinary way and the rest is handled at the same cost as it would be under the usual method. Care, however, must be exercised not to get the slopes too steep, as then they cannot be plowed economically, nor can a man stand on them with any ease to shovel.

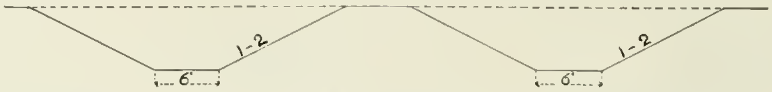


Fig. 1—A Method of Excavating Earth With a Wagon.

If a wagon can only be loaded from one side, and especially if the haul is long a side board should be used on the other side of the wagon. This will not interfere with the loading, yet it allows of a larger load being handled.

On account of the height of wagons, they should never be loaded by hand when other methods of loading are available.

In deep cellar excavation and in trenches, foundations and other confined places, wagons are often loaded by means of derricks. For this purpose derrick skips or some style of dump buckets are used. In many cases these are loaded by hand, then hoisted by the derrick and dumped into the wagons. A man will shovel a little more into a skip than into a bucket because it is lower, and more into either a skip or a bucket than into a wagon. However, there is the added cost of operating the derrick and shifting it from place to place, to suit the work. This added cost to the excavation is sometimes partially offset by doing away with a snatch team, and the horses are saved a sharp pull up a heavy grade to get the material from the pit. Large buckets and skips are generally to be preferred for this work, as then the wagon can be loaded without a wait for the derrick to return the empty and pick up another skip or bucket. In Fig. 2 is sketched a method of loading a bucket or skip by means of coring. The earth in this method is worked to a breast and the bucket or skip is placed directly against the breast or bank and then by means of picks and bars the material is loosened, allowing the great bulk of it to fall into the bucket. Any material that does not fall into the bucket is shoveled by the men. Under some circumstances this method will save a great deal of shoveling, thus reducing the cost of excavating.

A derrick car or a locomotive crane can be used to load wagons in the same manner as a derrick, but of course will cover more ground than an ordinary derrick. If the material is soft enough to dig it with a grab bucket, either an orange peel or a clam shell bucket can be used. This can be used with any of the three machines just mentioned. This does away with all shovel work except the trimming and dressing of the sides. The grab buckets are dumped directly into the wagons. Cable ways can also be used to load wagons in the same manner as a locomotive crane or a derrick.

Often wagons can be economically loaded by means of scrapers. Drag, buck or Fresno, or wheel scrapers can be used. Two runway ways are built to an elevated platform, one for the scraper to go up on, and the second one for leaving the platform. In the center of the latter a trap is cut, through which the dirt is dumped. The wagon is placed directly under the trap and is thus loaded. In deciding on the height of the dumping platform headroom must not only be allowed for the wagon, but also for the horses. This allows of the horses being driven under the trap and saves time in backing the wagon under the platform. One mistake often made in loading wagons with scrapers is to have too few scrapers in the run, thus making the wagon teams lose considerable time waiting on the scrapers. The best results are obtained when there are employed enough wagons to keep the scrapers going and also sufficient scrapers not to delay the wagons. Even when the proper number of teams are furnished the foreman

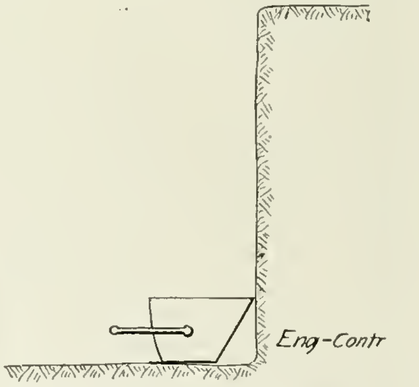


Fig. 2—A Method of Loading a Bucket by Means of Caving.

must use great vigilance to keep them in order and from blocking one another. When the grade to the platform or trap is a descending one both drag and buck scrapers can be used to great advantage, but when the grade is a steep ascending one, and the haul is a hundred feet or more, wheel scrapers are more economical.

One very efficient method of loading wagons is by means of an elevating grader. The wagon travels along with the excavating machine and is loaded without the wagon stopping. In order to start loading the elevating grader is generally stopped until the wagon has taken its position under the conveyor. In order not to delay the grader the empty wagons have to follow closely behind the machine so as to take their position under the conveyor promptly. In loading wagons with derricks, locomotive cranes, cable ways and scrapers, the height of the sides of the wagons does not particularly effect the operation of loading, but with elevating graders the height of the sides of the wagons does play some part. If the wagon body is very high the elevating conveyor has to be placed at such an angle that the excavated material is not readily carried on the conveyor, hence the work of the plow is interfered with to some degree, and the earth not being carried rapidly along the conveyor a much greater time is taken to load a wagon. It also takes more power to operate the grader.

Wagons can also be loaded in a manner similar to that done with elevating graders, with several styles of trench excavators. These trenching machines dig the earth with a series of small buckets with teeth on them, discharging the material onto a belt conveyor, as the plow of an elevating grader does. By driving wagons under the conveyor they are quickly loaded. These trench machines pulverize the earth so that the material dumps easily from the wagons, while with elevating graders the material is often in large clods. Most of the material excavated by trenching machines is deposited on the side of the trench to be used in back-filling over the pipe, sewer, or conduit, but the excess earth can be loaded into wagons as described and hauled away.

The practice of loading wagons with steam shovels is becoming more common each year. It was thought at one time that only cars were adapted for steam shovel work, but it has become more and more evident that under many conditions wagons are as well suited for this purpose as cars. The height of the wagon body does not effect the cost of loading, as when the dipper of the shovel is loaded it is at its greatest height and it has to be lowered to be dumped, either into a car or a wagon. This admits of a large capacity wagon being used in steam shovel work, with the additional advantage that the shovel will do more work per day in loading large wagons than with smaller ones.

The dipper of the shovel in loading wagons, even with the greatest care of the shovel runner, frequently knock the side boards of the wagon, thus breaking them. This objection to loading wagons with a steam shovel is readily overcome by using a hopper arrangement. The hopper is built large enough to hold a wagon load. It is supported on two bents, allowing the wagon to drive under the hopper. A gate operated by a lever holds the earth until the wagon is in position to receive it. This lever should be so placed so that the driver of the wagon can both release the gate and close it. The added expense of the gate quickly pays for itself, as then the wagon is loaded instantly, while with an open hopper it may take two or three dips of the shovel to load a large capacity wagon.

The hopper also prevents the dipper from spilling dirt around the wagon, thus impeding the wagons and necessitating the employment of extra men to keep the wagon road clear. The trestles of the hopper can be mounted on wheels, so as to allow it being moved forward as the shovel advances. Two men with bars can move the hopper or it can be run ahead with a bumper pole by the shovel, as the latter is moved. Such a hopper is also valuable in loading wagons when it necessary to have the shovel working on a higher elevation than the wagon. The shovel then drops its load into a chute that carries the earth into the hopper.

These hoppers will also be found moneysavers in loading wagons on the derricks, locomotive cranes or cable ways. When used in connection with these machines it is not necessary to mount them on wheels, as the hopper can be picked up by these machines and placed wherever desired. If heavy, sticky mud is being handled in the hoppers, an air jet introduced into the hopper will cause the hopper to be discharged quickly, saving the use of bars and shovels to clean out the mud.

(To be continued.)

The State Aid Law for the improvement of highways in New York State has been in operation for ten years. The following table shows what has been accomplished during that period.

During year	State aid to [illegible]	[illegible]	Miles [illegible]	Mi[illegible]
1898	$ [illegible]	$ [illegible]	[illegible]	[illegible]
1899	[illegible]	[illegible]	[illegible]	[illegible]
1900	[illegible]	[illegible]	[illegible]	[illegible]
1901	[illegible]	[illegible]	[illegible]	[illegible]
1902	[illegible]	[illegible]	[illegible]	[illegible]
1903	[illegible]	[illegible]	[illegible]	[illegible]
1904	[illegible]	[illegible]	[illegible]	[illegible]
1905	[illegible]	[illegible]	[illegible]	[illegible]
1906	[illegible]*	[illegible]	[illegible]	[illegible]
1907	[illegible]*	[illegible]	[illegible]	[illegible]
1908	[illegible]*	[illegible]	[illegible]	[illegible]
	$[illegible]	$[illegible]	[illegible]	1,[illegible]

*Part of this appropriation advanced for payment in first [illegible] of entire cost of roads by [illegible].

A New Hose for Rock Drills.

Every year the use of hose increases in construction work, and contractors are always on the lookout for a hose that will stand a high pressure and rough usage. The latter is very important as it seems to be almost impossible to get the ordinary workman to take care of a length of hose. Only a few days ago the writer was walking over a large job of rock excavation on which a large number of air and steam drills were used, and he noticed some four or five lengths of hose lying in the snow partly covered up and in such a position that they were bound to be walked upon.

A hose that will stand up under such treatment must necessarily be a good one. Realizing that a hose must meet such conditions to give satisfactory service, the Mulconroy Co., of 722 Arch St., Philadelphia, Pa., has just put on the market a new patented metallic hose. This hose is extremely flexible, and to coil it or bend does not injure it. It is stated that it will stand a pressure of over 1,000 lbs., and that it will not burst, collapse or kink.

The hose is also lighter in weight and is said to be cheaper than the ordinary hose. A special hose is made for rock drilling, that is suitable for either air or steam. The metallic covering used on this class of hose covers the entire hose, instead of leaving some exposed places. This company also manufactures hose for air brakes and many other uses.

Plastering Concrete Surfaces—The following statement regarding the plastering of concrete surfaces is made by Frederick A. Norris, in a paper read before the National Association of Cement Users. "There are many who believe that Portland cement and sand plaster cannot be put on a concrete surface and made durable because a proper bond cannot be formed between the backing and the surface, and that such plaster will crack and fall off in the course of time. It is possible, however, to make a durable surface in this way, and it has been done on many different pieces of work. It is absolutely necessary to have the face of the concrete thoroughly roughened up generally by tooling for the purpose of insuring a proper bond, and the surface must be thoroughly wet before the first coat of plaster is applied. This first coat must be thrown on with force, roughened up and allowed to set before the second coat is applied, because otherwise the weight of the second coat will tend to break the bond of the first coat. The second coat must then be applied in the same manner as the first coat. The finishing coat can then be floated or applied in any other manner desired, which is well known, after the second coat has been set and thoroughly wet down. The finish plaster should be kept covered and wet for at least one week. If large surfaces are to be treated, joints should be left to overcome [illegible]."

Roads and Streets Section

Note: This Section is devoted to methods and costs of road and street construction. It will cover road building in all its details, the construction of pavements, sidewalks and gutters, the testing and use of paving materials and the machinery and tools used in road building and paving.

Methods of Preventing Damage to Road Surfaces by High Speed Motor Cars.*

The manner in which the high-speed motor cars damage the road surface was discussed in a number of the papers submitted to the Congress. Much has been said about the suction of the broad rubber tires of motor cars drawing from the roadbed the binding material upon which its life depends, and while this is in a measure responsible for the dust nuisance and the rapid deterioration of highways subjected to heavy motor traffic, it is not the chief cause of damage. Stone roads, waterbound with screenings or sand, were designed to sustain a rolling traffic, and with reasonably broad tires and moderate speed, very little damage is caused by such traffic, although the loads may be very heavy. The motor car, however, is a self-driven vehicle, the power being usually applied to the rear axle, and the rear wheels act as driving wheels. The tractive force or shear exerted upon the road surface by these driving wheels is doubtless the chief cause of the injury which is so apparent. The fine dust or binding material is not so much sucked out of the roadway by the rubber tires as it is ground out and thrown into the air by the driving wheels. The observation of a fast moving car will show that this is the case. The dust raised by the forward wheels is slight and almost inappreciable on a road in good condition, while that raised by the rear wheels is very noticeable. This fact is brought out by the report presented by Mr. L. W. Page, Director of the United States Office of Public Roads, who was chairman of the American delegation to the Congress. It is also emphasized in the report of Professor Petot, of the Faculty of Sciences at Lille, who says:

"The reactions of wheels which are drawn may be neglected, but those of driving wheels may be very high. As the conditions of the surface layer of the ground to which these reactions are applied are unfavorable for resisting them, they are the main cause of wear and tear on roads traveled by automobiles. Hence it should be sought to give tangential cohesion and elasticity to the top surface of the roadway by a proper choice and arrangement of the materials of which it is made."

The recent deterioration of the surface of the highways of France is very noticeable, and M. Renardier estimates that fully 1,250 miles of these roads show a marked injurious effect resulting from automobile travel, this mileage being entirely on the national roads, which are those most frequented by automobiles.

While the roads of Great Britain are excellent, the system is not as complete as that of France. The roads have not been classified, and there is not the same uniform system of construction and maintenance. The damage caused to these highways by the automobile is quite as evident as in France, and the figures presented to the Congress showing the extent of this damage are quits as impressive. Mr. G. Montague Harris, secretary to the County Councils' Association, estimates that from 1896 to 1906 the cost per mile of maintaining the English macadam roads has increased 30.9 per cent in the case of rural main roads and 9.4 per cent in the case of urban main roads. Statistical data relative to the main roads in Nottingham County, England, show that while the increase in the annual cost of maintaining the highways from 1895 to 1900 was 4.7 per cent, the increase in the annual cost between 1900 and 1905 was 19.5 per cent. That the latter five-year period was coincident with the first general use of motor cars is certainly more than a coincidence. Another paper presented to the Congress showed that within five years the annual cost of maintenance of the rural main roads of England and Wales had increased 20 per cent, while during the same period the cost of maintaining roads of the same description in the seven counties nearest to London showed an average increase of nearly 38 per cent, and for the year ending in March, 1908, the increase in the same seven counties was nearly 48 per cent over that obtaining in 1901. Still another delegate to the Congress estimated the rise in the annual cost of maintaining the main roads of all of England and Wales during the past six years to be 21 per cent.

In this country accurate data concerning the life of roads and their constituent materials and the cost of repairs and maintenance have not been as intelligently kept as in Europe, but that this problem of the effect of the motor car upon our highways has forced itself upon those responsible for our roads is quite apparent. The State Engineer of New York in his last report suggests that "if the high-speed machines are to be allowed upon our highways they should be taxed in proportion to the maximum speed of which they are capable." He has also insisted that before any speed trials or road races by automobiles are held upon any of the highways under the control of the state, there shall be deposited in his office a very substantial sum in each case, which shall constitute a guarantee fund from which shall be paid the expense of repairing the damage caused by such races.

It is needless to give further testimony as to the extent of the damage now being done and the necessity for serious consideration of the problem which is presented, and of devising some method of solution.

The development of a system of good roads has always been a slow process. The Romans alone among the nations of the earth appear to have appreciated the potent influence of the highway upon civilization and commerce, and they planned and built their roads to stimulate the development of the country. Other nations have deferred their road building until the demands of traffic and the necessity for easy communication compelled it. During the last generation great progress has been made, and half a decade ago all progressive countries had not only paved their city streets with substantial, smooth and sanitary pavements, but had created systems of interurban roads in rural districts which were fairly smooth and relatively free from mud and dust, and upon which travel was comfortable and reasonably rapid with horse-drawn vehicle. Then came the motor car, and in a very few years conditions have changed to such an extent that the problem of maintaining the highways frequented by these vehicles is commanding universal attention. The cloud of dust raised by the motor car tells its own story. It means not only great discomfort for others using the road and those dwelling in its vicinity, but the very life of the structure is being taken from it. It is said that in a district near the City of New York well known for its excellent highways and in favor with the business and professional men of New York as a place of summer residence, it was formerly possible to live in entire comfort in a dwelling within a hundred feet or less of a public highway. Since the advent of the motor car the dust nuisance along these highways has become so serious that, to insure comfort, dwellings must be placed three or four hundred feet from the highways, necessitating the purchase of much more extensive grounds. The problem is not a fad or a fancy, but an acute condition which must be met.

How can the conditions which have been outlined be improved? Three solutions suggest themselves:

First—The speed of motor cars can be controlled by rigidly enforced police regulations, so that their effect upon the road will be no more destructive than that of the former horse-drawn vehicle.

Second—The motor traffic could be segregated and confined to roads built especially for it, and so constructed as to be dustless and unaffected by the rubber tired driving wheels and high speeds

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*From a report on the First International Road Congress submitted to the Board of Estimate and Apportionment of New York City by its Chief Engineer, Nelson P. Lewis.

Third—The roads could be gradually reconstructed with a binding material which will be proof against the disintegrating forces exerted upon them by motor cars running at high speed, and pending such reconstruction the roads could be so treated as to abate, if not entirely eliminate, the present nuisance.

The first plan is undoubtedly impracticable. To effectually police our suburban and country roads and prevent running at high speed would require an army of men, would involve enormous expense and would reduce the motor car, one of the most useful and remarkable mechanical developments of recent years, to a useless toy, if not an absurdity. It would be a confession of failure to cope with the problem and would be a long step backward, and may be dismissed without further comment.

The second plan, the segregation of motor traffic upon roads especially designed for it, might be possible, but would involve either a restriction of such traffic to very few roads, or a duplication of the present highway system at enormous expense. This expense, it might be claimed, should be imposed upon those using motor cars, either by tax or toll, as in the case of the motor parkway on Long Island, a section of which has been completed and upon which were held the last Vanderbilt cup races. This would mean that the cost of motoring would be so greatly increased as to be beyond the reach of any but the very wealthy. It would also be asked why, if the roads can be built to withstand this kind of traffic, the method should not be applied to our existing highways. Special motor roads will therefore be built, if at all, by private initiative, and at private expense, as is the case with the one referred to on Long Island, and will be used only for high speeding, which would be entirely inconsistent with public safety on the highways. Such a plan cannot be considered as a solution of the problem.

The third method, then, remains for serious consideration, and it is the one which was favored in nearly all of the reports presented to the Congress which dealt with the question of construction.

It must be conceded that grit or stone dust of the same kind as that of which the road is built, sand, sandy loam and mixtures of sand and clay, are not suitable as binding material for roads which are freely used by motor cars. As stated by M. Mauhieu, Engineer of Bridges and Roads, of Paris: "Only a perfectly homogeneous roadway, of which all the fine surface materials are protected against being scattered, is able to stand the passage of the extra rapid vehicles in use today." Either the roadbed must be so hard and dense as to be unaffected by the traffic or a more viscous and elastic binding material must be used. It is quite generally conceded that some form of bitumen is best adapted to this purpose. Many different kinds and grades are available—asphalt, tar, pitch and oil, and there are patented mixtures as to the efficacy of which extravagant claims are made, and patented devices for their application. The bituminous material may be used in various ways, but there are four general methods:

First—Coating the surface to form, temporarily, at least, a waterproof and dustless road.

Second—The penetration method, by which the bituminous matter is forced down into the broken stone, and sand or screenings are used to take up the excess of bitumen.

Third—The interposition of the bituminous mixture between the bottom course of stone (in many cases the existing road) and the top course, or new wearing surface, and the forcing of the upper course into the mixture, additional material being added to the surface to completely fill the interstices between the stones, while sand or screenings are applied to take up any excess upon the surface.

Fourth—The mixing method, under which the stone which is to form the wearing surface is thoroughly coated with the hot bituminous cement, with a proper amount of screenings and other fine material added to reduce the voids, the mixture being spread upon the road while hot, after which it is thoroughly rolled, as in the case of the ordinary asphalt pavement or bituminous macadam of the American type, the surface again being coated with sand or screenings, as in the other cases.

The first method, that of surface coating, can be considered temporary or palliative only. The material most commonly used is tar or oil, the latter being frequently applied as an emulsion.

The result of oil sprinkling on the parkways of Boston is given in a report presented to the Congress by Mr. John A. Pettigrew, Superintendent of Parks. The first application of the season is an emulsion containing about 16 per cent of oil. Renewals, which are made in from ten to twenty-five days, according to location and volume of traffic, contain from 8 to 10 per cent of oil. The cost of this treatment is said to be less than that of water sprinkling by more than 45 per cent. An oil emulsion quite similar to that used on the Boston parkways has recently been tried on the park roads in the Borough of Manhattan but there is no data at hand to determine the cost as compared with water sprinkling. Surface applications of tar have been quite successful, and the material is applied either by sprinkling or painting. Oil sprinkling is frequently applied to soft roads; tar is successfully used only on hard macadam. The proper method of applying tar to the surface of existing roads is given in a report presented by Colonel Charles S. Bromwell, Superintendent of Public Buildings and Grounds, Washington, D. C., one of the delegates to the Congress, as follows:

"Before applying the tar the macadam must be brought to grade and filled with fine screenings, rolled and subjected to traffic until firm. The mechanical bond of the macadam must be as perfect as possible, and no reliance should be placed on the tar to do the binding. Crude tars must not be used, as they contain ammonia and other objectionable substances. It is best to use one or more of the prepared tar products, which fulfill the physical and chemical requirements. The work should be done only in warm, dry weather. The macadam should be swept clean, and, if necessary, brushed with wire brooms, and the surface must be perfectly dry to a depth of at least one inch before applying the tar. The tar should be applied hot, at a temperature of about 200 degs. Fahr., allowed to percolate several hours, and then covered with sand or fine stone screenings. Several hours after the screenings have been spread it should be rolled and additional screenings put on, if the tar squeezes up through them. Traffic should be kept from the road for several days after the rolling in order to give the tar an opportunity to penetrate and become cool."

It is generally conceded that tar can only be successfully applied in fair and warm weather and when the surface of the road is entirely dry. The cost of tar painting, or surface treatment, is estimated at about one-half that of tar macadam laid by the mixing method hereafter described. This method of surface application is much in vogue at the present time on the highways in the vicinity of Paris, and even on some of the principal thoroughfares of the city itself. Some apparently excellent results have been obtained in this way, notably on the Avenue du Bois de Boulogne, a much traveled street, where the macadam pavement when seen by the writer had almost the appearance of asphalt. Tar sprinkling or painting has many enthusiastic advocates in France who make the most extravagant claims as to the efficacy of this treatment as a complete solution of the dust problem.

Mr. Clifford Richardson, one of the delegates of the Federal Government to the Congress, while recognizing the great temporary benefit of surface applications, concludes that attempts to save worn out roads in this way are doomed to failure. He believes that a dustless road can only be secured by the substitution of a bituminous concrete for the old type of macadam and that in constructing such a surface asphalt will give more satisfactory results than can be secured by the use of tar.

The second, or penetration, method consists of forcing the bituminous cement into the surface of existing or new macadam roads. If applied to an existing road the surface is first loosened, after which the hot tar or other bituminous matter is spread over the loosened stones, with the addition of a certain amount of screenings or other fine material, and the surface is then thoroughly rolled. The use of this method on new roads is described by Mr. Walter W. Crosby, Chief Engineer of the Maryland Road Commission, and one of the delegates to the Congress, as follows:

"The best method yet devised seems to be that of nearly completing the macadam as if no tar were to be used, and then, instead of finally 'flushing' (i. e., of filling the smallest voids with the finest sizes of stone by the aid of water), to saturate as nearly as possible the mass with refined tar heated to sufficient fluidity for penetration. Provided the irreducible interstices between the larger stones are filled with the smaller sizes down to the 'flour,' but the flushing in of the 'flour' has not proceeded to that point where the mass would be impervious to pentration by the tar, the results will be practically perfect. Successive applications of tar may be required, and some objection may be raised to the time required for this process. It would seem, however, that in view of the at least theoretically better results to be secured in this way, and of the fact that no sacrifice in economy of materials nor of any of the principles underlying the construction of macadam is involved, that some extra length of time in the process might be justified. It is entirely possible that, in the investigations regarding the bituminous cement to be used, a vehicle for carrying it swiftly into its place in the stone aggregate may be found so that this objection will be met, or at least reduced to the minimum."

The third method, or the interposition of the bituminous mixture between the bottom and top courses, is best typified by what is known as the Gladwell system, and was described by Mr. Gladwell himself, Engineer and Surveyor to the Eton Rural District, England, in a paper presented to the Congress. After the foundation course, which is frequently the surface of an old road, has been brushed clean, a binding material composed of a bituminous cement mixed in proper proportions with screenings or shippings of fine, clean granite, quartzite, basalt or other hard stone is spread upon the surface. Upon this binding material is placed a layer of ordinary broken stone, with no special preparation except careful breaking and the elimination of dust and small particles. A small amount of this binding material is then lightly spread and brushed into the surface interstices and the surface is rolled until the mass is fairly solid. A top dressing of hot, bituminous cement in the proportion of about one quart to each square yard is flooded over the surface, after which it is sprinkled with clean chippings, or screenings, of the same character as those already described as forming the binding material, and the surface is then thoroughly rolled. The cost of this treatment is given by the County Surveyor of Fife, Scotland, as from 8 to 12 cents per square yard more than that of ordinary macadam.

The fourth, or mixing, method is perhaps more expensive than those already described, but it is probable that this method will be more likely than any of those yet mentioned to result in a road which is structurally and inherently dustless. What is known as Bitulithic pavement is of this type, but in Bitulithic special care is taken to grade the mineral matter as to size in order to produce a wearing surface of great density, and the cost of the pavement is too great to permit its use upon rural highways.

There has been laid in the Borough of Richmond a limited amount of what is called asphalt macadam, in which the mixing method has also been followed, and the results appear to be excellent. The State Board of Public Roads of Rhode Island has built some miles of this type of highway with most satisfactory results. The methods used are given in a paper read before the American Society of Civil Engineers by Mr. A. H. Blanchard, who is in immediate charge of this work. The roads have been examined by the writer and were found to be in almost perfect condition and entirely free from dust. A number of these roads were built under contracts let for ordinary macadam, the State Board having agreed with the contractor to adopt the new method of construction, the contractor crediting the board with the value of work not required, the board furnishing the bituminous cement, and the extra work being paid for at cost plus 15 per cent. The cost of tar macadam constructed by the mixing method was 12 cts. per sq. yd. greater than the contract price for ordinary macadam. The cost of a similar macadam in which the bituminous cement was composed of one-half tar and one-half asphalt was 13.3 per cent greater than that of ordinary macadam, while the resulting road was especially satisfactory. A similar construction in which tarvia was used as the bituminous cement exceeded in cost the ordinary macadam by 15.1 cts. per sq. yd. This slight difference in cost was undoubtedly due to excellent management and careful oversight, and similar results would not be obtained except under equally careful supervision, but it has been demonstrated that at an increased cost within the reach of any community it is possible to secure a dustless road incomparably better adapted than is ordinary macadam to motor car traffic. Meanwhile it has been shown to be possible to overcome in a large degree the present dust nuisance by surface treatment consisting of the application of a binding material. This binder may be temporary only in its effects, such as light oils, tars and emulsions and solutions of various salts, having marked affinity for water, thereby keeping the road surface in a moist condition. The results obtained on the Boston parkways by the use of oil emulsions have already been noted. The binder may be of a more permanent character, such as heavy oils, tars and liquid asphalts, one application of which will under moderate traffic prevent the formation of dust to any great extent for an entire season. Such treatment should not be applied in a haphazard way, but should be the subject of careful investigation to determine the material and method of application best suited to the existing condition. An excellent paper upon this subject by Mr. Prevost Hubbard, Assistant Chemist, Office of Public Roads, has recently been issued by the United States Department of Agriculture as Bulletin No. 34 of the Public Roads Bureau. In it the author says: "It is undoubtedly true that thousands of dollars are wasted annually in a repetition of experiments which have time and again proved costly mistakes. On the other hand, experiments which have given good results in some places have also proved failures when tried in different locations. It is necessary, therefore, not only that the experience of others be considered, but that some thought be given to the probable effect of local conditions upon the results which have in general been obtained. * * * Differences in composition and physical qualities (of the materials used) will often explain the fact that under otherwise similar conditions both good and bad results have been obtained. Discrepancies in results, however, are often obtained under varying conditions when the same material is employed in each case." Mr. Hubbard's paper should be carefully read by every highway engineer in the city's service.

A new electric dredge is to be constructed for the Outer Harbor Dock & Wharf Co., of Los Angeles, Cal., and will be used for the hydraulic dredging work of the company. The contract for the dredge has been let to the United Iron Works of Los Angeles. The machine will have a maximum capacity of 220 cu. yds. per hour, or 5,000 cu. yds. per day of 24 hours. The current power will be supplied by the Edison Electric Co. at a voltage of 2,200 volts. The hull will be built and the dredge launched from the Outer Harbor Dock & Wharf Co.'s grounds and the machinery will be supplied by the local companies of Los Angeles. There will be two 2,000 volt, 50 cycle, 3 phase motors of the Westinghouse C. C. L. pattern and a cutter specially designed to cut the clay material found in the space behind the U. S. Government breakwater and the Timms Point bluffs. This dredge will embrace all the newest improvements in its line and also many specially designed features never before used.

Cost of Patching Asphalt Pavement, Using a Small Repair Plant.

BY T. E. PETRIE.*

The accompanying data relate to repair work in the city of Marion, Ind., throughout the month of September, 1908. This is a very good average of the season's work, after the force was thoroughly organized and all equipment put into service.

A city of the size of Marion could not afford a plant costing upwards of $20,000, which would possibly remain idle eleven months out of the year; so we had to look for a smaller and less expensive repair plant. We have in our city 6.64 miles of asphalt streets, or 123,486 sq. yds. The first street was constructed in 1899 and the last in 1902. While we have some excellent asphalt streets, some are much below the average. We found in past experience that to rely on the asphalt companies to do our repair work, it was necessary that our streets should become quite bad before any company would agree to come in to do our repair work, as the repair yardage was so small that it would not pay them to move their plant to our city, so we could expect them once in two or possibly three years, even though the street was under guarantee.

In the spring of 1908, even though two of our streets were yet under guarantee, our Board of Public Works came to an agreement with the Barber Asphalt Co., that the city should take care of all streets under guarantee and that the Barber Asphalt Co. would relinquish all retainer claims that they held against the city.

In the meantime three of our streets became quite bad, so we began to look about for some relief, and finally purchased one of Hooke's largest combined asphalt plants and a carload of asphalt. To this plant was added another pan and a 700-lb. hand roller.

The cost of the plant was as follows:

Combined fire wagon and asphalt heater	$465
Freight	42
Extra pan	43
Hand roller	65
Hand cart	10
Total cost of plant	$625

Depreciation on the plant was figured on the basis of 60 days' use for the season. This, at 10 per cent, amounted to $62.50 or $25.72 for the 25 days for which the cost records are given.

We began work July 20, 1908, and finished or rather run out of material, Nov. 28th. While not working quite all the time we laid 4,142 sq. yds. of patch work. Great care was taken about the work and it is almost impossible to detect many places where patches were made. We used the Acme asphalt, which came already fluxed, and three grades of sand, so as to obtain as nearly a standard mix as possible, as well as to make the mixture as dense as possible.

We used Portland cement as a filler, instead of stone dust, which caused the price per sq. yd. to run up somewhat higher than it would have had stone dust been used. We had two experienced men in the gang and paid them 25 cts. per hour, all other men were paid 20 cts. per hour. A one-horse dump cart was used for hauling material from stock room to plant, also hauling prepared material to street, and cuttings or old asphalt away, usually hauling same on some nearby street as repairing material. The cart man was paid 27½ cts. per hour. The full repair gang consisting of eight men, three out on the street and five at the plant, and one horse cart and driver. Orders were given to work until the pans were cleaned and filled with sand at the end of each day's work, ready for fire the next morning. Four-foot wood was generally used for firing, costing $5.50 per cord, yet some shorter wood was used, costing $1.75 per cord. The Portland cement cost $1.40 per barrel; sand cost $0.75 at the plant and the asphalt cost $30 per ton f. o. b. Marion.

DAILY OUTPUT AND COST FOR PATCHING ASPHALT STREETS AT MARION, IND.

Date (1908).	No. of sq. yds laid	Cost of labor at 20 and 25 cents.	Cost of asphalt, including freight, at $30.00 per ton.	Cost of sand at plant, 75 cts. per yd.	Cost of cement, $1.40 per bbl.	Cost of fuel $5.50 per cord	Cost of cartage, 30 tons of asphalt	Interest on plant investment, at 6%	No. cubic feet
Sept. 1	59.9	$20.15	$14.56	$3.00	$4.20	$3.12	$0.48	$0.62½	117⅓
Sept. 2	54.7	20.15	14.56	3.00	4.20	3.12	0.48	0.62½	117⅓
Sept. 3	54.7	20.15	12.74	2.62½	3.67½	2.73	0.42	0.62½	102⅓
Sept. 4	66.0	20.15	14.56	3.00	4.20	3.12	0.48	0.62½	117⅓
Sept. 5	60.3	20.15	14.56	3.00	4.20	3.12	0.48	0.62½	117⅓
Sept. 8	58.7	19.35	14.56	3.00	4.20	3.12	0.48	0.62½	117⅓
Sept. 9	59.8	20.15	14.56	3.00	4.20	3.12	0.48	0.62½	117⅓
Sept. 10	58.2	20.72	14.56	3.00	4.20	3.12	0.48	0.62½	117⅓
Sept. 11	30.8	20.15	9.10	1.87½	2.62½	1.95	0.30	0.62½	73⅓
Sept. 12	41.4	20.15	14.56	3.00	4.20	3.12	0.48	0.62½	117⅓
Sept. 14	52.9	20.15	14.56	3.00	4.20	3.12	0.48	0.62½	117⅓
Sept. 15	60.6	20.15	14.56	3.00	4.20	3.12	0.48	0.62½	117⅓
Sept. 16	56.6	20.15	14.56	3.00	4.20	3.12	0.48	0.62½	117⅓
Sept. 17	53.2	20.15	14.56	3.00	4.20	3.12	0.48	0.62½	117⅓
Sept. 18	56.2	20.15	14.56	3.00	4.20	3.12	0.48	0.62½	117⅓
Sept. 19	56.0	20.15	14.56	3.00	4.20	3.12	0.48	0.62½	117⅓
Sept. 21	56.6	20.15	14.56	3.00	4.20	3.12	0.48	0.62½	117⅓
Sept. 22	50.3	20.15	14.56	3.00	4.20	3.12	0.48	0.62½	117⅓
Sept. 23	52.0	20.15	14.56	3.00	4.20	3.12	0.48	0.62½	117⅓
Sept. 24	54.5	20.15	14.56	3.00	4.20	3.12	0.48	0.62½	117⅓
Sept. 25	60.8	20.15	14.56	3.00	4.20	3.12	0.48	0.62½	117⅓
Sept. 26	53.0	20.15	14.56	3.00	4.20	3.12	0.48	0.62½	117⅓
Sept. 28, p. m.	19.5	10.15	5.46	1.12½	1.57½	1.17	0.18	0.31¼	44
Sept. 29	48.2	20.15	14.56	3.00	4.20	3.12	0.48	0.62½	117⅓
Sept. 30, a. m.	33.3	10.27	7.28	1.50	2.10	1.56	0.24	0.31¼	58⅔
25 days	1308.0	$483.64	$340.34	$70.12½	$98.17½	$72.93	$11.22	$15.00	2742*

*Cost per cu. ft., $0.407.

During the 25 working days in September a total of 1,308 sq. yds. of asphalt pavement of an average depth of 2 ins. was laid. The itemized cost was as follows:

	Total.	Per. sq. yd.
Labor	$ 483.64	$0.3697
Asphalt, including freight	340.34	2602
Sand	70.12	0536
Cement	98.17	0750
Fuel	72.93	0557
Cartage	11.22	0086
Interest	15.00	0114
Depreciation	25.72	0120
Total	$1,117.14	$0.8538

Last season was an excellent one to do repair work, on account of there being but little rain. The sand was kept as dry as possible, and therefore was covered at night, and at daytime in case of rain. This materially assisted in the progress of the work as well as in the saving of much fuel.

The plant was located at some convenient point, near where considerable patching was to be done and care was taken not to move the plant too frequently, as this expense will cause the price per square yard to rise quite rapidly. We were able to get out eight batches per day, providing everything worked well. It is intended to enlarge the mixing pans before beginning work this season, and by so doing it is hoped to increase the output fully 25 per cent, and by using stone dust instead of Portland cement for filler, to cut the price down to at least $0.75 per sq. yd. or perhaps lower.

In the tabulation I give the daily report throughout the month of September, 1908, showing cost of various materials used and labor cost, also showing total cost of plant and allowing interest on plant investment at 6 per cent, making total charges against the 60 days, as average time plant will be in use each season, also depreciation at 10 per cent for the same period. There has been nothing allowed for superintendence of the work as either the city engineer or his assistant will have time to see that work is going on as it should. However, last season I gave this work quite considerable attention, measuring all patches made, as I desired to know just what it was costing per square yard.

I do not anticipate that we will have as much repair work in the next two seasons as we had last season. I understand that one of our neighboring cities has purchased a plant costing about $11,000, and having possibly about the same or a little less number of square yards of asphalt to maintain as we have in our city. I do not see any economy in a plant of that kind and I would suggest as a compromise between the extremes, that four or five cities in close proximity join in purchasing a plant that could be moved from one city to another, making the plant as nearly portable as possible; this would divide the cost of the plant as well as dividing amount of interest and depreciation charges.

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*City Engineer, Marion, Ind.

This plant could be used in resurfacing as well as patching, and no doubt satisfactory arrangements could be made, as to time, that each city was to use the plant, as ordinarily from two to three weeks would be sufficient time for doing the patch work at any one place; yet in case of resurfacing, from four to six weeks might be consumed.

I should be pleased to have this matter thoroughly discussed, as the keeping of our asphalt streets in repair "in the smaller cities" is surely a continual drain on the general fund.

The U. S. Civil Service Commission will hold competitive examinations this spring for the following positions: Civil engineer: Department Service; civil engineer, Philippine Service; civil engineer and draftsman; civil engineer and superintendent of construction; civil engineer student. Computer: Coast and Geodetic Survey; Nautical Almanac Office; Naval Observatory; Supervising Architect's Office. Draftsman: Apprentice, Ordnance Department; architectural; copyist, topographic; engineer; heating and ventilating; junior architectural; mechanical, Isthmian Canal Service; topographic, Department Service; topographic, Isthmian Canal Service; engineer, Indian Service; forest assistant, Forest Service; forest assistant, Philippine Service; superintendent of construction. Application forms and information in regard to these examinations may be obtained by addressing the U. S. Civil Service Commission, Washington, D. C., or the Secretary of the Board of Examiners at the following-named places: Postoffice, Boston, Mass.; Philadelphia, Pa.; Atlanta, Ga.; Cincinnati, O.; Chicago, Ill.; St. Paul, Minn.; Denver Colo.; San Francisco, Cal.; custom house, New York, N. Y.; New Orleans, La.; old custom house, St. Louis, Mo.

The New York State Civil Service Commission, Albany, N. Y., will hold examinations on Feb. 27 for the following positions: County superintendent of highways in various counties; resident engineer, State Water Supply Commission, at $2,400 per year. Applications must be received by Feb. 20. Further information may be obtained from the Chief Examiner, State Civil Service Commission, Albany, N. Y.

Unclassified and General Articles

Note: This section is devoted to methods and cost articles on construction work not properly coming under any of the preceding classifications.

Education of Inspectors at the Contractors' Expense.*

BY JAS. FORREST.†

Usually papers presented before meetings of this kind are technical treatises about recently advanced theories on design or methods of construction and uses of materials, or else they are descriptions of a design, manner of prosecuting work, or a write-up of some new-fangled machine. But, in a measure to be original and to present a subject of much vital financial interest and importance to contractors and those paying for work done and of some benefit to young engineers, and old ones too for that matter, it has been decided to present this for your attention, discussion, and approval or disapproval.

It is not the intention to tell you something that you do not already know. It is to bring before you, as a sort of a reminder, this very important question of inspection which in the past seems to have been entirely overlooked and neglected.

The up-to-date contractor, in looking up new work, always endeavors to procure certain information aside from material prices and labor conditions. The first and most important being the pay, if it is sure and prompt. The next to be looked after are the hazards, risks and obstacles that are liable to be met with and must be overcome. The next to be learned, if possible, is, who the inspector is to be. Here the enumeration will stop as he is to be the subject matter of this paper.

The probabilities are that the inspector, engineer in charge, superintendent of construction, or supervising engineer, whichever his vanity leads him to designate himself, will be one of the following: A recent technical graduate; an under-graduate staying out a year to replenish his wallet; an old retired engineer; a personal friend of some politician; a political heeler who controls some votes and must be on the pay roll, or, if the job and the contractor are lucky or fortunate, he might possibly be an engineer of ability, experience and judgment, who was temporarily out of employment, or a contractor's foreman or superintendent in the same predicament.

Now any of these may be dishonest and eager of pollution, which, if taken advantage of by the contractor, will cause him no loss as it would return many fold in decreased costs. However, very few, if any, contractors who intend to stay in business will stoop to buying inspectors as they generally get stung for it later. This phase of the question need not be discussed here as the part intended to be covered by this paper is that where the contractor suffers through the ignorance, lack of judgment, overconscientiousness, or bull-headedness on the part of the inspector.

If all the contractors get wise that they are liable to get the worst of it all through the work the bids will be higher than necessary. In that case the remedies to be mentioned later could be applied and those paying for the work would be greatly benefited. Again this paper is digressing as it is from the contractors' standpoint that the question is supposed to be discussed.

Consider the condition that nothing has been added to take care of the shortcomings of the inspector and see what is liable to happen, first describing generally the present specifications and the method of obtaining them.

Years ago it was customary to let contracts on very primitive plans and specifications, sometimes both entirely lacking, relying on the honesty and experience of the contractor for results. The great opportunity offered by this condition developed a class of avaricious contractors whose sole object seemed to be to skin a job, doing as little for the pay they got as was possible. This crookedness became so evident that plans and specifications were made more specific and exacting with varying amounts of superfluity and impossibilities until there exists today specifications that cannot be followed to the letter. If bids were based upon strict adherence to them they would be much higher. And if made to live up to the absolute letter of them a badly bent contractor would be the result. Specifications as they are today place the contractor's money entirely at the mercy of an engineer who too often is unfit to be entrusted with anything. It must be borne in mind that often plans and specifications are prepared by incompetent engineers and to follow all of them would be to return to many old and worn-out theoretical ideas and practices that have long since been discarded by the prominent and up-to-date engineers and contractors.

The customary duties of an inspector or engineer in charge are to furnish all engineering data consisting of lines, grades, etc., and to see that plans and specifications are followed honestly, using judgment in their interpretation. He should deviate from them when the welfare and progress of the work are at stake, allowing the contractor extra compensation for any extra work, should there be any, and when any unforseen difficulties arise that absolutely prevent them from being followed. An example of the first would be the specification requiring the plastering of any exposed concrete surfaces. This should always be disregarded. An example of the latter would be the one met with in river foundations work requiring that no concrete be placed in water. This is a fair and legitimate specification but if the work should happen to be in quick sand it is almost impossible to get all the water out of the cofferdams and an inspector with judgment and experience knows that concrete can be placed in water successfully if the proper methods and precautions are used and he should permit it. He must of course see that it is properly done, permitting no slighting of the work. Failure to permit a deviation similar to this letter would work an unnecessary hardship on the contractor without any particular gain in the quality of the work.

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*A paper presented at the annual convention of the Iowa Association of Cement Users held at Des Moines, Iowa, Feb. 2, 3 and 4, 1909.

†Des Moines, Iowa.

Some examples of the lack of judgment, experience and fairness on the part of inspectors might well be mentioned to show the financial and time losses and inconveniences necessarily suffered by contractors in being made to live up to the absolute letter of the specifications and carry out patent and new-fangled ideas both in regard to finished work and methods of obtaining it, invented by the inspectors and insisted upon by them. In some cases enmity toward the contractor, selfishness in prolonging the job, possibly some fear because of the lack of experience and an inflated opinion of their own prowess and intelligence are the probable causes. Piles 2 ins. short of specified length were rejected, even though 2 ft. were cut off after being driven in the foundation pits. Specifications called for stone with dust screened out. Many cars of stone were rejected because in shipping the friction of the pieces of soft limestone on each other produced a little dust. Longitudinal expansion joints of freak design were ordered placed in the skew-backs and arch haunches, the reasons for which were not given, except that they wanted them. The furnishing of levels as soon as asked was refused because the specifications required that the inspector be notified a certain length of time before any lines or grades were desired. It was insisted that piers be washed and rubbed down to the footings 6 ft. below low water. After a day's concreting in a pier footing it was insisted that the pump run till 9 o'clock at night, and it was a sad sight to see the good cement being pumped out. But as it cost a little extra it was demanded, when every one knows, or should know, that concrete sets the best under still water. It seemed in some cases that the specifications were deviated from only when it cost the contractor more, even to the detriment of the bridge. They were strictly adhered to whenever the expense remained great with no particular gain to the bridge. An inspector on a steel building would permit [illegible] painting [illegible] [illegible]. The [illegible] [illegible] the point would be [illegible] [illegible] the rust in the steel [illegible] [illegible] would [illegible] [illegible] the point. [illegible] [illegible] [illegible] posted as to the porosity of steel [illegible] [illegible] to control the density of a steel building. There are inspectors who have required cold rivets which have been [illegible] by driving, to be cleaned of rust by hand with a piece of emery paper. Some inspectors have graduated from college many years ago and more is expected from them, but it seems that they are rather cut out for street car conductors.

Many other very unpleasant things come up on large work where one or more inspectors are working under a head inspector or engineer, each with their special duties to perform. A sub-inspector will instruct the contractor to proceed with a certain part of the work in a certain manner. As soon as he is rigged up and well started, along comes the "big chief" inspector and orders it done in an entirely different manner.

A very frequent case where both the structure and the contractor suffer is when piles are required to be driven till the final penetration is the same as that mentioned in the specifications. The point at which to cease hitting a pile is a very difficult one to determine. It is entirely a matter of judgment. If specifications are strictly adhered to in regard to the amount of the final penetration a badly shattered, broomed, or sheared pile with a consequent weakened foundation and a greatly inconvenienced contractor often result.

There seems to be no recourse from the unreasonable demands of an inspector as he is nearly always empowered to discharge any man on the work. Consequently there is nothing for the contractor to do but to take his medicine and grin. It is mysterious that there have not been a great many charges of assault and battery with intent to do great bodily injury filed by inspectors against contractors' foremen and superintendents or even the contractors themselves.

Here is an example of an engineer who was reasonable and fair, and used judgment, when he could have caused a lot of trouble if he hadn't. A concrete arch bridge of several spans was built. The plans and specifications called for a certain number of steel rods in the bottom of each slab. One rod was accidentally omitted in one of the slabs and was only discovered when an extra one was found after the bridge was done. The number of rods had been checked when they arrived and there were no extras, so one must have been left out. Now if the plans and specifications had been insisted upon to the letter when this rod was discovered the bridge could have been ordered torn down till the slab which was lacking one rod was located and then rebuilt before being accepted. But the engineer was fair enough [illegible] [illegible] [illegible] [illegible] [illegible] and [illegible] [illegible] [illegible] [illegible] to know that the [illegible] was [illegible] [illegible] [illegible] be [illegible] it. [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] inspector [illegible] [illegible] [illegible].

One of the causes [illegible] [illegible] [illegible] is due to the fact that [illegible] [illegible] plans and specifications. This can be remedied by employing only competent [illegible] experienced [illegible] [illegible] [illegible] pared work [illegible] [illegible] [illegible]. By doing this [illegible] [illegible] [illegible] work in every particular with reference to the specifications will be [illegible] [illegible] relieving the inspector [illegible] [illegible] call upon his judgment.

Another of the causes is that too small salaries are paid inspectors to procure competent ones. To overcome this the salaries should be increased enough to attract the attention of capable and experienced men now employed by leading engineering and contracting firms. The importance of the position of the engineer in charge must be appreciated and realized and salaries commensurate therewith paid.

As long as the present salaries are paid a few suggestions for those who may be attracted by them might help. If he is experienced he ought to learn the reputation of the contractor as to honesty, experience and ability, and watch him or his representatives for a while to see if he intends to maintain that reputation on this new work. If he is satisfied, he can [illegible] [illegible] engineering data and pass only on finished work. Let him keep his mouth shut and eyes open and trust to the experience of the contractor to do the work in the proper manner. He must always bear in mind that specifications were not intended to be and cannot be followed to the letter and keep his eye open for any sign of dishonesty or slighting. By doing this if he is properly constructed, he will become, after being on two or three pieces of work, too valuable to last longer as an inspector and will be gobbled up by some contractor.

An inspector does not need to be [illegible] experienced and afraid of dishonesty on the part of the contractor to work [illegible] hardships on the latter. He can be mean and unfair and insist upon the letter of the specifications. That will do it. But if he tries to be mean and overbearing he might discover that the contractor was wiser and sharper than he was and could and would skin the job right under his nose without him being able to detect it. The inspector and contractor must work in harmony to produce a first class piece of work at minimum cost and the former bear in mind that he is more interested in results than in the methods of obtaining them and that the contractor can usually use his own established methods much more advantageously, economically and effectually than [illegible] another's.

If an inexperienced inspector [illegible] [illegible] conduct himself as pointed out in the [illegible] going, when the job is completed he will be much better educated as an inspector, but oh my! at what a great expense to the contractor.

An Adjustable Steel Drawing Table.

The accompanying cut shows a steel drawing table that has been placed on the market by The Century Manufacturing Co., Columbus, O. The construction is of special high carbon steel angles with the Century system of bracing. The table is absolutely rigid, stiff, strong, light in weight and can be adjusted to any height for sitting or standing, or to any incline of top from horizontal to vertical. It can be folded up flat for transportation or storage. The stand or sub-structure alone can be furnished for one's present board, and easily attached by means of screws through metal cleats. The table can be furnished either with or without parallel straight edge equipment and adjustable instrument tray as shown.

Century Steel Drawing Table.

It is proposed by forty or more engineers of the state of Wisconsin representing cities, public utilities, colleges and manufacturing plants, to organize a state society along the same lines as those which are now in existence in Illinois, Indiana and other states. The purpose of this society is to get the engineers of the state better acquainted with each other and to get a better understanding of problems that are of mutual interest to all and to discuss some of the leading municipal and other problems of the day. It is proposed to hold the first meeting in Madison, Wis., in the Engineering Building at the University of Wisconsin on Feb. 24, 25 and 26. Prof. F. E. Turneaure, Dean of the College of Engineering, is chairman of the program committee, and W. G. Kirchoffer, 31 Vrooman Building, Madison, Wis., is secretary of this committee, to whom all correspondence should be addressed.

The value of building permits granted by municipal authorities in 63 leading cities, as reported to the Bureau of Statistics, Department of Labor and Commerce, aggregated $585,913,633 for the past year, compared with $656,067,969, the total for the calendar year 1907.

LETTERS TO THE EDITORS.

Wages on the Panama Canal.

Sirs:—The writer has been following with much interest your articles on the excessive cost of day work on the Panama Canal.

I have never seen it shown up in your magazine, or in fact in any other, that this work is of such a character that it could be cut up into smaller contracts, and by this means a great saving could be effected. Of course, W. J. Oliver & Co. would have used this method if they had been successful in getting the work, and what is good business for W. J. Oliver & Co., should be good business for the United States of America.

It would be interesting in determining the excess cost of the canal work, to take the men on the canal and compare their wages with what they formerly received on like work in the States. I know of one instance where a bridge carpenter, or rather bridge foreman, received $75 on a railroad in the States, is now receiving $200 per month on the canal for the same class of work. A like analysis of the entire pay roll would probably show the same ratio of increase.

Yours very truly,
F. J. Manley,
308 City National Bank Bldg.
Lexington, Ky., Jan. 29, 1909.

Reinforced Concrete Boats in Italy.

Sirs: I note in the issue of Jan. 13 of Engineering-Contracting a statement that the concrete boats and barges now being used in Italy are not a success and that they have been discontinued. It is further stated that your authority is a consular report.

Allow me to state that I was in Italy for several weeks and that I gave a great deal of my time to the investigation of this subject and I have found that reinforced concrete boats and barges are widely used and that they are giving their owners excellent service. The Italian Marine is using them in large numbers and have recently ordered a large number for additional service.

Furthermore, no U. S. Consular report, to my knowledge, has ever given an adverse report upon these constructions, but if you will take the trouble to go into the matter carefully you will find that our consul at Rome, where the boats are made, has written a very good report on them dated Nov. 10 and 11. I have personally talked with the consul there and I know he thinks very highly of the construction.

You may find in the "Cement Era" of Chicago for November a descriptive article giving some facts about the matters in question.

You are doing the builders of these boats, as well as concrete construction in general, an injustice in printing a report like this.

Very truly yours,
H. Prime Kieffer.
42 Broadway, New York City, Jan. 22, 1909.

(The statement to which our correspondent takes exception was made by Consul General James A. Smith and the wording of the "Consular Report" is given nearly verbatim in our item of Jan. 13, 1908.—Editors.)

The Meaning of Cost Per Square Foot of Surface Contact for Concrete Forms.

Sirs: In Engineering-Contracting for Jan. 13, 1909, in the tables on cost of reinforced concrete what is meant by surface contact in square feet on the carpenter labor? Suppose a column were 18x18 in. x12 ft., which would be 72 ft. inside surface, do you take that as the amount of square feet in figuring the cost, without regards to the thickness of lumber or clamps used on same? The way I figure it in square feet, if 2-in. plank were used without any clamps, there would be 160 ft. of lumber. In regards to floor beams or girders is the cost in your table given in surface contact without regard to the posts or shores used to support same? Any information you can give me in regard to this would be very much appreciated.

Yours very truly,
M. J. Danielson.
Portland, Ore., Jan. 23, 1909.

(The form costs given in the tables referred to by our correspondent are costs per square foot of concrete surface covered by forms; they have no reference to the board measure of the form lumber. For floors the costs do not, we assume, include bracing and staging, but this is a matter which the author of the tables does not make clear in his paper. We have started inquiries regarding some of the uncertain points and trust shortly to be able to give full data.—Editor.)

A Method of Keeping Records.

Sirs:—As a contribution to the subject of records, I will say that a method I have finally adopted after trial of many, is to make all calculations on a sheet, or on as many sheets as are necessary, and to file these calculation sheets, with the letters, in a vertical letter file.

As engineer for a reinforcing company many inquiries come to me wherein some calculations have to be made. A rubber stamp bearing the date is used to mark a sheet of paper of letter size and on this stamp is provided spaces for the number of the job, the number of the sheet (if several), the name of the man figuring the job, name and address of the inquirer. This stamp occupies a space of about 2 ins. square in the upper left hand corner. All the calculations in detail are made on these calculation sheets, and if any diagrams must be drawn quadrille ruled paper is used. Generally, however, the paper is plain. Care is taken to have every step plainly indicated so that the matter will be fully understood no matter at what date it has to be referred to. The calculations end with a full bill of material and the prices. Sometimes the order may come in weeks or months after and the material can be quickly ordered when order is received.

Reply to the letter is made with carbon copy on the back of the letter of inquiry instead of being on separate flimsy sheet. The letter then, with carbon copy of reply on the back is filed in the letter file together with all the correspondence from that party.

If the inquiry is about some special structure a blank sheet is prepared, having at the top the name of the structure. Under that is given the name of the party making the inquiry and the date and the notation "See file of ————." Another sheet is prepared, having the name of the town or city as a heading and underneath is the same information, so that we then have the matter indexed under three headings all referring to the same file; to wit, to the name of the inquirer; to the name of the town or city; to the kind of structure.

The office boy has a folder for each and it is impossible to lose any of the work done. This system has the advantage that no separate card index is required, but the man making all the calculations can prepare his reference sheets at the time he starts his calculations. Sometimes we have the matter indexed under locality and class of work several days before the calculations are completed and filed in the folder of the inquirer.

For a great many small jobs the calculations are made on the back of the letter of inquiry, in which case, of course, the carbon copy of reply is made and filed in the ordinary manner.

If a traveling man goes into a certain territory the letter files can be looked over for all the places he will strike. If any of these places have had folders prepared for them we can give him a list of all the work we have done or contemplated doing there, and he knows on whom to call and how to talk to the parties. We find the plan very convenient.

Yours truly,
Ernest McCullough,
Chief Engineer, Northwestern Expanded Metal Co.,
Chicago, Ill., Jan. 30, 1909

Publishing Engineering Estimates.

Sirs: The editorial in ENGINEERING-CONTRACTING of Feb. 3 emphasizes a thought the writer has had in mind for some time, viz., a change in attitude of the engineering profession on the question of publishing cost estimates.

As a body of professional men we are slow to admit that an engineer's capital consists not in a mere aggregation of facts and figures, but in his experience and personal development. We have the erroneous idea that when we publish cost data, we give away our experience; the fact being that experience, like education, is a part of the man and cannot be imparted. The most that we do is to furnish the other man a standard by which he may calibrate his own experience.

To my mind, cost estimates should receive as wide publicity as specifications, in fact, be a part of them. The course of reasoning, resulting from many years of experience in the engineering and contracting field, can best be presented by a few thoughts on the various methods of contracting.

From earliest times, the *lump sum* contract has been practically universal; with the result that large losses have alternated with phenomenal profits. This has brought contractors into ill repute, honest ones going into other lines of work and the business being conducted as a gambling venture with politics on the side.

Then came an improvement—the *unit cost* contract; in effect, dividing large work into a number of lesser contracts. This led to unbalanced bidding with its train of allied abuses; still, the method was a distinct advance, raising the standard of honesty, and inducing a few engineers to enter the field.

Within the past few years, the *cost plus a percentage*, quickly followed by *cost plus a fixed sum*, form of contract was advocated and tried. It is not too much to say that with the advent of these two methods, the old form of contract lost its prestige, the ignorant and too frequently dishonest contractor ceased to be representative of the class, the business assumed the ethics of a profession and engineers quite generally engaged in the work. It was but natural that fixed profits and percentages should prove too tempting where the morale of the business was low, and where the method inherently failed to make identical the interests of both parties to the contract.

Having tried these various methods, with all sorts of modifications, the writer has advanced a new method, and would like the views of other engineers and architects as to its adequateness and adaptability to existing needs. It can best be described as

Cost plus a fixed sum, with bonus and forfeit clause regarding both the time limit and the total expenditures, all extras to be paid for by cost plus a percentage.

This presupposes that the bidder will have his architect or engineer make complete plans and specifications, together with an itemized and detailed estimate of cost, giving time limit. This would include the proposed plan of operation upon which the estimate was based. While [illegible] would never be carried out in its entirety by the contractor, yet it would give a general [illegible] not only at the time of bidding but during the progress of the work.

It would definitely formulate the requirements as to equipment and men—how much and what kind of machinery, how many superintendents, engineers, foremen, timekeepers, clerks, mechanics and laborers. It would give the size and make-up of each gang, and time required for different portions of the work, correlating them as to their necessary sequence, both as regards the disposition of the working force and the plant employed on each. The local conditions would be given fully, for on them depends the best method of handling the work.

Each bidder would then go over these, using his own judgment as to local conditions and the correctness of the estimate, and submit his bid as usual. The bid would include a percentage for doing the work, and a bonus and forfeit clause, dependent on the actual cost of the work and its time of completion.

If bidders considered an estimate low and the time of completion short, they would ask a high percentage with a low bonus and forfeit clause, expecting to pay a forfeit out of their percentage, leaving reasonable profits after this is deducted. On the other hand, if the estimate were high and the time long, they would undertake the work for a low percentage but put in a high bonus and forfeit clause, expecting to receive bonus money with which to augment the percentage. In the case of federal, state and municipal work, the bonus and forfeit would be a matter of law, the bidding being simply on the percentage.

A correct view of what is needed in the construction field is more readily obtained if one gets first a clear conception of the true function of the contractor—the economic need for his existence. This is twofold:

Knowing where and how to best buy machinery, materials and supplies,

Ability to organize and operate a working force—both men and plant equipment—so as to secure the maximum efficiency.

Considering the contractor a necessary evil has been very expensive both to the building public and the general taxpayer. With a realization of his field of usefulness comes the certainty that the contract of the future will harmonize the interests of the builder and contractor, instead of antagonizing them as in the past.

In order to draw up an equitable contract, or judge of one that is drawn, the true requisite is that it shall be fair to both parties, presuming them both to be honest and actuated by right motives. The second is to have it formulated so there is no incentive for dishonesty by either party—so that whether an honest or dishonest course is followed it will result in a gain or a loss to both parties, never a gain to one and a loss to the other.

The form of contract advocated would accomplish this purpose. In order to carry it out fully on works of considerable magnitude the engineer would issue preliminary plans, specifications and estimates; thus allowing for conferences with such contractors as cared to embrace the opportunity. This would give the fullest publicity, and with the form of contract outlined, could not fail to improve the status of legitimate contracting.

The foregoing conclusions have been reached by experience as an owner, as an engineer for contractors and municipalities, as a contractor on both public and private works, and as a consulting engineer.

Very truly,
JEAN BART BALCOMB,
Assoc. M. Am. Inst. E. E.

1104 The Temple,
Chicago, Ill., Feb. 6, 1909.

In a report on the first International Road Congress Mr. Nelson P. Lewis, chief engineer of the Board of Estimate and Apportionment of New York city, states that Paris, France, on Jan. 1, 1908, had 2,464,900 sq. yds. of wood pavement. The wood pavements, the report states, are made for the most part of native pine from the Landes, though some Baltic or other northern fir is used. The paving blocks are made and creosoted at a plant owned by the city of Paris. The joints between the blocks are usually filled with cement grout. The cost of wood pavements is slightly less than those of asphalt, being from $2.70 to $3 per sq. yd., with a 6-in. concrete foundation. The cost of current maintenance is about 5 cts. per sq. yd. annually, while the total estimated cost of wood pavements, including cleaning at 12½ cts. and a renewal of the surface at the expiration of nine years, is given as 39 cts. per sq. yd. Contracts call for no guarantee except to make good any defective workmanship during the first year, but this does not apply to defects in the blocks themselves. The life of a wood pavement in Paris varies from six to ten years, with an average of nine years. Where there is practically no traffic it will last for 15 years, when it will rot and renewal becomes necessary. When the upper surface of the blocks becomes worn and uneven, they are taken up, the worn surface is trimmed off on the street by special gasoline or electrically driven machines, and the blocks are relaid with the trimmed surface down.

Catalogs Worth Having.

Engineers and contractors should have on file the latest catalogs of machines, tools and supplies that they use. In sending for catalogs reviewed or advertised in this paper, you will confer a favor on us if you will write direct to the advertisers and state that you saw the catalog mentioned in ENGINEERING-CONTRACTING. If you are in the market for tools, machinery or supplies, tell us and we will notify promptly the leading manufacturers.

No. 1080. **"Willey" Electrically Driven Tools.**—Jas. Clark, Jr., Electric Co., Inc., 1340 Old Colony Bldg., Chicago, Ill.

This catalog describes a number of electrically driven machine tools, the motor and tool being combined into one machine. Among the tools illustrated and described are screw feed portable drills, electric hand drills, and electrically driven breast drills. A compact electrically driven hack saw weighing 310 pounds is also described.

No. 1081. **Hoisting Engines and Derricks.**—American Hoist & Derrick Co., St. Paul, Minn.

This 185-page catalog is a very handsome book, well bound and profusely illustrated. It illustrates and describes the various products of this company, namely, hoisting engines of all kinds, derricks and their fittings, locomotive cranes, derrick cars, jet cranes, pile drivers, bridge builders, derrick cars, tower derricks, barge derricks, skips, buckets and tubs, and wire ropes.

No. 1082. **Condensers.**—Dean Bros. Steam Pump Works, Indianapolis, Ind.

A 56-page catalog devoted to condensing machinery. Numerous air pumps and jet condensers are illustrated and described and much valuable information is given regarding condensers.

No. 1083. **Road Building.**—The A. L. Barber Asphalt Co., 90 West St., New York.

A 28-page essay on road construction written in an attractive style. It will no doubt be of interest to many engineers and contractors engaged in road construction.

No. 1084. **Derrick Swinging Machines.**—Mead-Morrison Mfg. Co., Cambridge, Mass.

A very nicely gotten up catalog of 20 pages showing the style of hoisting engines manufactured by this company for operating derricks on construction work, especially in reference to swinging derricks.

No. 1085. **Road Rollers.**—J. I. Case Treshing Machine Co., Racine, Wis.

A well gotten up 20-page catalog showing all the features that go to make good the claim that this company's roller is an economical one to use. The catalog is well illustrated with handsome half-tone cuts. This company also manufactures traction engines and sprinkling wagons.

No. 1086. **Steam and Air Hose.**—The Mulconroy Co., 722 Arch St., Philadelphia, Pa.

A 10-page catalog and price list of this company, giving prices on air brake hose and couplings, boiler washout hose, pneumatic hose, water hose, ring and sheet packing and hose couplings.

No. 1087. **Electric Hoists.**—Mead-Morrison Mfg. Co., Cambridge, Mass.

A 44-page catalog, well printed, describing and illustrating electric hoists for many different purposes. Various parts are also described and tables showing size and hoisting capacity are given. Electric transporters and cranes are also listed.

No. 1088. **Air Compressors.**—Thos. H. Dallett Co., Philadelphia, Pa.

A 24-page catalog telling of the air compressors manufactured by this company. The various parts of a compressor are illustrated and described, and tables showing sizes and capacity of various types of machines are given.

No. 1089. **Friction Clutches.**—The Carlyle Johnson Machine Co., Hartford, Conn.

A very attractive little 36-page catalog illustrating and describing friction clutches for various kinds of machinery. The Johnson clutch is well known and hardly needs describing.

No. 1090. **Wheelbarrows.**—Sterling Wheelbarrow Co., Milwaukee, Wis.

A folder showing the various styles of wheelbarrows and buggies manufactured by this company. Any one interested in concrete work or earth and rock excavation should have this folder. Several of these barrows show a radical departure from the ordinary barrow, and allow a larger load to be carried with less labor by the workman.

No. 1091. **Contractors' Supplies.** — The Cockburn Barrow & Machine Co., Jersey City, N. J.

A 24-page catalog illustrating and describing the Cockburn wheelbarrows, buggies, dump buckets and tubs, side, end and bottom dump cars, punching machines, concrete mixers, grout mixer and ejector, steam hammer, air lock, tunnel shields, concrete dump buckets, cable grips, sand pumps, air lock governor and other articles.

No. 1092. **Concrete Houses.** — Concresco Construction Co., 225 5th Ave., New York.

An 8-page catalog telling of the patents owned by this company to make a block and a concrete wall for concrete houses.

Personals.

Mr. E. Ben Carter has been appointed Superintendent of Maintenance of Way of the Florida East Coast Ry.

Mr. Orson A. Miller has been reappointed City Engineer of Oneonta, N. Y., this making ten consecutive years that he has held that position.

Mr. Max Burgdorf has been appointed Chief Engineer for the proposed standard gage railroad to be constructed from Beaver to Penrose, Colo.

Joseph Caccavajo, Consulting Engineer, 2 Rector street, New York, has been retained as Consulting Engineer in connection with some proposed railways in Japan.

Messrs. W. L. Allen, B. W. Ely and Geo. B. Pugh have organized the Port O'Connor Construction Co., of Victoria, Tex., and will engage in a general construction business.

Mr. R. E. Comfort, heretofore Superintendent of the Interoceanic Railway of Mexico, at Pueblo, Mexico, has been appointed General Superintendent, succeeding F. W. Baldwin, deceased.

Mr. J. M. Stark has been appointed Engineer of Construction on the extension of the Chicago, Rock Island & Gulf Ry. in western Texas and of the allied company building the extension in New Mexico.

Mr. H. F. Cameron has resigned his position as Chief Engineer of the Board of Public Works of Santiago de Cuba to accept the position of Railroad and Highway Engineer to the Bureau of Public Works, Manila, P. I.

Mr. Warren Wood, of the Wood Drill Works, Paterson, N. J., and Mr. Robert J. Wood, manager of the Chicago branch, will leave the United States on Feb. 21st for a three weeks' visit to the Panama Canal Zone.

Mr. M. C. Byers, heretofore Engineer of Maintenance of Way of the St. Louis & San Francisco R. R., has been appointed Chief Engineer to succeeded Mr. J. F. Hinckley, who has resigned to engage in private practice as consulting engineer.

Mr. George E. Ferris, of Pittsburg, Pa., has gone to Solomon City, Idaho, to take the position of Division Engineer on the construction of the new Harriman line being built from Armstead, Mont., through Solomon City to a point 120 miles west of Armstead.

Mr. W. C. Nones has been elected Chairman of the Sewerage Commission of Louisville, Ky., in succession of Mr. Peter Lee Atherton. Mr. Nones has been vice-chairman for some time. Mr. Atherton retired from the chairmanship on account of ill health, but he will continue as a member of the commission.

Charles MacRitchie, a civil engineer and water-works and tunnel contractor, died Jan. 27, at his home in Chicago, aged 66 years. Mr. MacRitchie came to Chicago from Inverness, Scotland, in 1869. He directed the building of several sewers and water tunnels, not only in Chicago, but in other large cities of the United States and Canada.

Mr. C. G. Young, with Mr. J. N. H. Cornell as an associate, has opened an office at 60 Wall street, New York, to engage in engineering construction work. Mr. Young will make a specialty of examinations and reports on projects for financing. He will be absent in the Orient from March to August, making examinations and reports on a number of projects in the Philippine Islands, China, Japan and Siberia. For seventeen years Mr. Young has been associated with the J. G. White & Co. in handling construction and making reports on work in nearly every part of the world. During his absence his office will be under the direction of Mr. Cornell.

Jose Francisco de Navarro, promoter of many important industrial enterprises, died Feb. 3 at his home in New York City, aged 85 years. He was born in Spain, and was graduated as a midshipman from the Spanish Royal Naval Academy. He was a number of years in Cuba previous to coming to this country. In 1855 he organized the firm of Mora & De Navarro, which operated the first steamship line between this country and Brazil. Later he took a leading part in organizing the Ingersoll Rock Drill Co. and the Atlas Portland Cement Co. He remained active in the affairs of the latter company until about a month before his death. He had an active part in the construction of some of the early elevated railways in New York City. He also built the Navarro apartment house in Central Park South, New York, the pioneer structure in this country to furnish every luxury and convenience of the best hotels with the seclusion of private houses.

CONTRACT NEWS

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We shall welcome any news notes that our readers may send in. Notes of contracts awarded, bidding prices, etc., will be especially acceptable.

BIDS ASKED

Bridges.

Bids Open.		See Issue.
Feb. 10.	Fort Des Moines, Ia.	Jan. 27
Feb. 12.	Grand Forks, N. Dak.	Jan. 27
Feb. 12.	Dungannon, Va.	Feb. 10
Feb. 15.	Norwalk, O.	Jan. 27
Feb. 15.	Lisbon, O.	Jan. 27
Feb. 15.	Lynchburg, Va.	Feb. 3
Feb. 15.	Bowling Green, O.	Feb. 10
Feb. 16.	Waseca, Minn.	Jan. 27
Feb. 18.	Chicago, Ill.	Feb. 10
Feb. 20.	Cleveland, O.	Jan. 27
Feb. 25.	Westmoreland, Kan.	Feb. 10
Mar. 2.	Faulkton, S. Dak.	Feb. 3
Mar. 2.	Grafton, N. Dak.	Feb. 10
Mar. 3.	Cleveland, O.	Feb. 10
Mar. 4.	Paris, Ark.	Jan. 13
Mar. 6.	Cleveland, O.	Feb. 10
April 5.	Harrisburg, La.	Feb.

Buildings.

Feb. 10.	National Soldiers' Home, Va.	Jan. 20
Feb. 10.	Stanford, Ky.	Jan. 20
Feb. 10.	Brooklyn, N. Y.	Feb. 3
Feb. 11.	Dulce, N. Mex.	Jan. 13
Feb. 11.	Clarinda, Ia.	Jan. 13
Feb. 11.	Madisonville, Tenn.	Jan. 20
Feb. 11.	Fort Slocum, N. Y.	Feb. 3
Feb. 11.	Washington, D. C.	Feb. 3
Feb. 11.	Pittsburg, Pa.	Feb. 10
Feb. 12.	Cleveland, O.	Feb. 3
Feb. 12.	Fort Oglethorpe, Ga.	Feb. 3
Feb. 13.	Watkins, N. Y.	Jan. 27
Feb. 13.	Fort Niagara, N. Y.	Feb. 3
Feb. 15.	Fort Monroe, Va.	Jan. 27
Feb. 15.	Grand Rapids, Mich.	Jan. 13
Feb. 15.	Shenandoah, Ia.	Jan. 13
Feb. 15.	Fort Dupont, Del.	Jan. 20
Feb. 15.	Grand Rapids, Mich.	Jan. 20
Feb. 15.	Patton, Cal.	Feb. 3
Feb. 15.	Brawley, Cal.	Feb. 3
Feb. 15.	Christiansburg, Va.	Feb. 10
Feb. 15.	Athens, Tenn.	Feb. 10
Feb. 15.	Plymouth, Mass.	Feb. 10
Feb. 16.	Youngstown, O.	Jan. 27
Feb. 16.	Washington, D. C.	Jan. 20
Feb. 16.	Wheeling, W. Va.	Feb. 3
Feb. 16.	San Bernardino, Cal.	Feb. 3
Feb. 17.	Redfield, S. D.	Jan. 20
Feb. 17.	Salisbury, N. C.	Jan. 20
Feb. 17.	Anadarko, Okla.	Feb. 3
Feb. 17.	Great Falls, Mont.	Feb. 3
Feb. 17.	Richmond, Ky.	Feb. 3
Feb. 17.	Redfield, S. Dak.	Feb. 10
Feb. 18.	Greenville, Miss.	Jan. 20
Feb. 18.	Newton, Ia.	Jan. 27
Feb. 18.	Baltimore, Md.	Feb. 10
Feb. 18.	Pittsburg, Pa.	Feb. 10
Feb. 19.	Fort D. A. Russell, Wyo.	Feb. 3
Feb. 20.	Bar Harbor, Me.	Jan. 20
Feb. 20.	Americus, Kan.	Feb. 3
Feb. 23.	Fort Riley, Kan.	Jan. 27
Feb. 23.	Abilene, Tex.	Feb. [illegible]
Feb. 23.	Dodge City, Kan.	Feb. [illegible]
Feb. 23.	Los Angeles, Cal.	Feb. [illegible]
Feb. 24.	Sigourney, Ia.	Jan. 27
Feb. 24.	Washington, D. C.	Feb. 3
Feb. 24.	Gowanda, N. Y.	Feb. 10
Feb. 24.	Ogdensburg, N. Y.	Feb. 10
Feb. 25.	Hot Springs, S. Dak.	Feb. 10
Feb. 25.	Fitzgerald, Ga.	Feb. 10
Feb. 26.	Fort Snelling, Minn.	Feb. 10
Feb. 27.	La Salle, Ill.	Jan. 13
Mar. 1.	Omaha, Neb.	Jan. 6
Mar. 1.	Gadsden, Ala.	Feb. 3
Mar. 1.	Fort H. G. Wright, N. Y.	Feb. 10
Mar. 1.	Fort Snelling, Minn.	Feb. 10
Mar. 2.	Atlanta, Ga.	Feb. 3
Mar. 3.	Augusta, Me.	Feb. 3
Mar. 3.	Middletown, N. Y.	Feb. 10
Mar. 6.	National Soldiers' Home, Tenn.	Feb. [illegible]
Mar. 8.	Atlanta, Ga.	Feb. [illegible]
Mar. [illegible]	Elizabeth, N. J.	Feb. [illegible]
Mar. 10.	Winnipeg, Man.	Feb. [illegible]
Mar. 10.	Moline, Ill.	Feb. 10

Roads and Streets.

Feb. 10.	Baltimore, Md.	Feb. [illegible]
Feb. 11.	Appleton, Wis.	Dec. 30
Feb. 12.	Lafayette, Ind.	Feb. 3
Feb. 1[illegible].	Indianapolis, Ind.	Feb. 10
Feb. 15.	Whipple Barracks, Ariz.	Jan. 27
Feb. 15.	St. Paul, Minn.	Feb. [illegible]
Feb. 15.	Paris, Ill.	Feb. [illegible]
Feb. 15.	Upland, Cal.	Feb. [illegible]
Feb. 15.	Chicago, Ill.	Feb. 10
Feb. 15.	Philadelphia, Pa.	Feb. 10
Feb. 15.	St. Paul, Minn.	Feb. 10
Feb. 16.	Milford, O.	Feb. [illegible]
Feb. 16.	Toledo, O.	Feb. 10
Feb. 16.	Boonville, Ind.	Feb. 10
Feb. 17.	Chicago, Ill.	Feb. 10
Feb. 17.	Cleveland, O.	Feb. 10
Feb. 17.	Brooklyn, N. Y.	Feb. 10
Feb. 18.	Spencer, Ind.	Jan. 27
Feb. 18.	Spencer, Ind.	Jan. 20
Feb. 18.	Greenwood, S. C.	Feb. 3
Feb. 18.	Oakwood, O.	Feb. 3
Feb. 18.	Greenfield, Md.	Feb. [illegible]
Feb. 19.	College Hill, Pa.	Feb. 10
Feb. 25.	Fort Williams, Me.	Feb. 3
Feb. 26.	Waukesha, Wis.	Feb. 10
Mar. 1.	Vevay, Ind.	Feb. 10
Mar. 1.	Liberty, Ind.	Feb. 10
Mar. 1.	Danville, Ind.	Feb. 10
Mar. 2.	Wabash, Ind.	Feb. 10
Mar. 2.	Bloomington, Ind.	Jan. 27
Mar. 4.	Corning, N. Y.	Feb. 10
Mar. 4.	Wabash, Ind.	Feb. 10

Sewers.

Feb. 10.	Detroit, Minn.	Jan. 27
Feb. 10.	Brooklyn, N. Y.	Feb. 3
Feb. 11.	Brantford, Ont.	Jan. 27
Feb. 12.	Indianapolis, Ind.	Feb. 10
Feb. 15.	Santa Cruz, Cal.	Feb. 3
Feb. 15.	Atlanta, Ga.	Feb. 3
Feb. 16.	Ashtabula, O.	Jan. 27
Feb. 17.	East St. Louis, Ill.	Jan. 20
Feb. 17.	Baltimore, Md.	Feb. 3
Feb. 20.	Denton, Tex.	Feb. 3
Feb. 22.	Natchitoches, La.	Feb. 10
Feb. 24.	Rochester, N. Y.	Feb. 10
Feb. 24.	Kings Park, N. Y.	Feb. 10
Feb. 26.	Louisville, Ky.	Feb. 10
Mar. 1.	New London, Conn.	Feb. 10
Feb. 19.	College Hill (P. O. Beaver Falls), Pa.	Feb. 10

Water Supply.

Feb. 12.	Cincinnati, O.	Feb. 10
Feb. 15.	New Ulm, Minn.	Jan. 20
Feb. 15.	Sebree, Ky.	Jan. 20
Feb. 15.	Itta Bena, Miss.	Feb. 3
Feb. 15.	Milwaukee, Wis.	Feb. 10
Feb. 17.	International Falls, Minn.	Feb. 3
Feb. 17.	Elkhart, Ind.	Feb. 10
Feb. 19.	Decatur, Ill.	Feb. 10
Feb. 20.	Webster, N. Y.	Feb. 3
Feb. 20.	Colfax, Ill.	Feb. 10
Feb. 23.	Mabton, Wash.	Feb. 3
Feb. 24.	Owosso, Mich.	Feb. 3
Mar. 1.	Milwaukee, Wis.	Feb. 10
Mar. 1.	Rock Island, Ill.	Feb. 10
Mar. 4.	Fort Assinniboine, Mont.	Feb. 10
Mar. 15.	Wichita, Kan.	Jan. 20

Miscellaneous.

Feb. 11.	Mobile, Ala.	Pontoons,	Jan. 2[illegible]
Feb. 11.	Mont Alto, Pa.	Gas Generators,	Feb. [illegible]
Feb. 11.	Indianapolis, Ind.	Wire Fence,	Feb. 10
Feb. 12.	Milwaukee, Wis.	Concrete Caissons,	Jan. 20
Feb. 12.	Ottawa, Ont.	Grand Stand,	Feb. [illegible]
Feb. 13.	Hawaii.	Dry Dock,	Dec. 9
Feb. 15.	Rock Island, Ill.	Street Lighting,	Feb. [illegible]
Feb. 15.	Milwaukee, Wis.	Hauling,	Feb. 10
Feb. 17.	Albany, N. Y.	Rebuilding Fire Engine,	Feb. [illegible]
Feb. 16.	Frankfort, Mich.	Pier Work,	Jan. 2[illegible]
Feb. 18.	Fort [illegible], Fla.	Fence,	Feb. [illegible]
Feb. 27.	San Francisco, Cal.	Pier,	Feb. [illegible]
Mar. 1.	Des Moines, Ia.	Electric Plant,	Feb. 10
Mar. 1.	Tiburon, Cal.	Coal Sheds,	Feb. 10
Mar. [illegible]	Milwaukee, Wis.	Incineration Plant,	Feb. [illegible]
Mar. [illegible]	Savannah, Ga.	Dike Work,	Feb. 10

Excavation, Earth and Rock.

Feb. 10.	Logan, Ia.	Ditch Work,	Jan. 6
Feb. 11.	Red Lake [illegible], Minn.	Ditch Work,	Feb. 3
Feb. 11.	Redwood Falls, Minn.	Ditch Work,	Feb. 3
Feb. 1[illegible].	Dakotah, Ia.	Ditch Work,	Feb. 3
Feb. 1[illegible].	[illegible]	Dam,	Feb. 10
Feb. 1[illegible].	Paw Paw, Ill.	Ditch Work,	Feb. 10
Feb. 1[illegible].	Valparaiso, Ind.	Ditch Work,	Feb. [illegible]
Feb. 1[illegible].	Valparaiso, Ind.	Tile Ditch,	Feb. 10
Feb. 18.	Fowler, Ind.	Ditch Work,	Jan. 27
Feb. 19.	Willow Lake, Minn.	Ditch Work,	Feb. 3
Feb. 1[illegible].	Alexandria, Minn.	Ditch,	Feb. 10
Feb. 2[illegible].	Harvel, Ill.	Ditch Work,	Feb. [illegible]
Mar. 3.	Fairmont, Minn.	Ditch Work,	Feb. 3
Mar. [illegible]	Buffalo, N. Y.	River Improvement,	Feb. 10

Materials, Machines, Supplies, Etc.

Feb. 10.	Phoenix, Ariz.	Pumping Engine,	Jan. 27
Feb. 10.	Baltimore, Md.	Tile,	Feb. 3
Feb. 10.	Baltimore, Md.	Electric Light Posts, Etc.,	Feb. 3
Feb. 10.	Indianapolis, Ind.	Asphalt,	Feb. 3
Feb. 11.	Kansas City, Mo.	Water Pipe,	Feb. 3
Feb. 11.	Duluth, Minn.	Pumps,	Feb. 3
Feb. 11.	Washington, D. C.	Rope, Pumps, Jacks, Etc.,	Feb. 3
Feb. 11.	Pittsburg, Pa.	Filing Cases,	Feb. 10
Feb. 12.	Minneapolis, Minn.	Sewer and Paving Brick,	Feb. 10
Feb. 12.	Boston, Mass.	Water Pipe,	Feb. 10
Feb. 13.	Chicago, Ill.	Cable,	Feb. 10
Feb. 15.	Superior Entry, Wis.	Piles,	Jan. 20
Feb. 15.	Savannah, Ga.	Paving Blocks,	Jan. 27
Feb. 15.	Washington, D. C.	Track Supplies,	Jan. 27
Feb. 15.	Sherman, Tex.	Pipe, Hydrants, Etc.,	Feb. 10
Feb. 15.	Haskell, Tex.	Pumps, Pipe, Etc.,	Feb. 10
Feb. 16.	Virginia, Minn.	Fire Hose,	Feb. 10
Feb. 17.	Milwaukee, Wis.	Gas Producer and Gas Engine, Electric Light Plant	Jan. 13
Mar. 17.	Portland, Me.	Mooring Stones,	Feb. 1[illegible]
Feb. 1[illegible].	Baltimore, Md.	Cement Stone,	Feb. [illegible]
Feb. 18.	Calgary, Alta.	Boilers, Generator,	Feb. 1[illegible]
Feb. 18.	Calgary, Alta.	Rails, Wire, Poles, Etc.,	Feb. 1[illegible]
Feb. 22.	Winnipeg, Man.	Pump, Motor,	Dec. 9
Feb. 2[illegible].	Washington, D. C.	Block Valves, Etc.,	Feb. 3
Feb. 24.	Saskatoon, Sask.	Pumping Engine,	Feb. 10
Mar. 1.	Lethbridge, Alberta	Electrical Mach., Etc.,	Jan. 27
Mar. 1.	Muskogee, Okla.	Pump,	Feb. 10
Mar. [illegible]	Grand Rapids, Mich.	Stone,	Feb. 10

BIDS ASKED

Bridges.

Bids are asked on following work, the notices being arranged alphabetically by states.

Chicago, Ill.—Bids will be received until [illegible] Feb. 18 by Department Public Works, John J. Hanberg, Commissioner, for furnishing all materials, all labor, tools, apparatus and appurtenances and the performance of all necessary operations including transportation and field for the completion of repairs and reinforcements of the Van Buren St. bridge, consisting of renewing the structural steel supports for the counterweights at the rear end of the leaves, placing an additional roadway stringer under each inner street car rail on the bridge and approaches, reinforcing the cantilevering parts of the stationary floors, etc.

Westmoreland, Kan.—Until 2 p. m., Feb. 25, by H. G. Huckstadt, County Clerk, for constructing a 300-ft. long steel approach to the Stockdale bridge over the Blue River.

Grafton, N. Dak.—Until 2 p. m., Mar. 2, by Q. M. Fraser, County Auditor, for the erection of all pile and stel bridges to be erected during the year 1909, and also for repairs to bridges.

Bowling Green, O.—Until Feb. 15, by County Commissioners, for placing creodone block floor on bridge in Center Township.

Cleveland, O.—Until 11 a. m., Mar. 6, by County Commissioners, Wm. F. Black, Clerk, for the construction of bridge work, per report No. 2217, new substructure, Mastick Road, Rocky River; report No. 2218, steel bridge, Mastick Road, over Rocky River. A. B. Lea, County Surveyor, New Court House, W. 3rd St., Cleveland.

Cleveland, O.—Until 11 a. m., Mar. 3, by County Commissioners, W. F. Black, Clerk, for bridgework, per report No. 2210, pipe and embankment, Stone Road, Independence Township.

Dungannon, Va.—Until Feb. 12, by P. St. J. Wilson, State Highway Commissioner, Richmond, Va., for construction of steel bridge over Clinch River at Dungannon, Va.

Buildings.

Bids are asked on following work, the notes being arranged alphabetically by states:

Fitzgerald, Ga.—Until Feb. 25, by Mayor J. G. Knapp, for erection of a new school building here.

Moline, Ill.—Until 3 p. m., Mar. 10, by James Knox Taylor, Supervising Architect, Washington, D. C., for construction, complete, of the U. S. Post Office at Moline.

Baltimore, Md.—Until noon, Feb. 18, by Wyatt & Nolting, Architects, Keyser Bldg., Baltimore, for the erection of an Administration Building and two or three cottages on the site of the Maryland School for Boys, near Loch Raven, Baltimore County, Md.

Plymouth, Mass.—Until 3 p. m., Feb. 15, by County Commissioners, for electric work, plumbing, heating, roofing, windows and doors for the County Jail. J. W. Best, Architect, 58 Summer St., Boston, Mass.

Fort Snelling, Minn.—Until 11 a. m., Feb. 26, by R. C. Croxton, Constructing Quartermaster, Army Bldg., St. Paul, Minn., for constructing ice house at Fort Snelling.

Fort Snelling, Minn.—Until 11 a. m., Mar. 1, by Capt. R. C. Croxton, Constructing Q. M., Army Bldg., St. Paul, Minn., for constructing, plumbing, electric wiring and electric fixtures of a quartermaster stable at Fort Snelling, Minn.

Elizabeth, N. J.—Until 3 p. m., Mar. 9, by James Knox Taylor, Supervising Architect, Washington, D. C., for the construction, including plumbing, gas piping, heating apparatus, electric conduits and wiring, of the U. S. Post Office at Elizabeth.

Fort H. G. Wright, N. Y.—Until 10 a. m., Mar. 1, by Capt. Charles T. Baxter, Constructing Q. M., New London, Conn., for the construction of a bakery building, plumbing, and installing heating apparatus and electric wiring and fixtures in same, at Fort H. G. Wright, N. Y.

Gowanda, N. Y.—Until 3 p. m., Feb. 24, by State Commission in Lunacy, T. E. McGarr, Secretary, Albany, N. Y., for tuberculosis hospital, construction, including heating, plumbing and electric work; and cold storage building and storeroom, construction, including heating, plumbing and electric work, at Gowanda State Homeopathic Hospital, Gowanda, N. Y. Franklin B. Ware, State Architect, Albany, N. Y.

Middletown, N. Y.—Until 3 p. m., Mar. 3, by State Commission in Lunacy, T. E. McGarr, Secretary, Albany, N. Y., for hospital for acute insane, construction, including heating, plumbing and electric work; conduits for nurses' home and farmer's house, construction, including steam piping and electric cables; day rooms annexes, construction, including heating and electric work; pavilion for contagious diseases, construction, for the Middletown State Homeopathic Hospital, Middletown, N. Y. Franklin B. Ware, State Architect, Albany, N. Y.

Ogdensburg, N. Y.—Until 3 p. m., Feb. 24, by State Commission in Lunacy, T. E. McGarr, Secretary, Albany, N. Y., for dormitory at Inwood, construction, including heating, plumbing and electric work, at St. Lawrence State Hospital, Ogdensburg, N. Y. Franklin B. Ware, State Architect, Albany, N. Y.

Pittsburg, Pa.—Until 10:30 a. m., Feb. 18, by Edward G. Lang, Director Department Public Safety, for decorating engine house No. 37 on Rebecca near Columbo St., also for decorating engine house No. 38, corner Lemington Ave. and Missouri St. Kiehnel & Elliott, Architects, Publication Bldg., 209 9th St., Pittsburg.

Pittsburg, Pa.—Until 10 a. m., Feb. 11, by Department Public Works, A. B. Shepherd, Director, for erection and completion of porch for field house at Lawrence Park.

Hot Springs, S. Dak.—Until noon, Feb. 25, by W. A. Tucker, Treasurer Battle Mountain Sanitarium, N. H. D. V. S., for constructing a tuberculosis ward.

Redfield, S. Dak.—Until Feb. 17, by R. Howell, Chairman of Committee, for erection of a County Jail building here.

Athens, Tenn.—Until Feb. 15, by W. Z. Long, Chairman Board of Education, for erection of a school building here.

National Soldiers' Home, Tenn.—Until noon, Mar. 6, by Paul E. Divine, Treasurer, Mountain Branch, N. H. D. V. S., National Soldiers' Home, for furnishing all labor and material necessary for the complete construction of Surgeon's quarters. Bids are also asked for furnishing all labor and material necessary for the complete construction of Chaplain's quarters.

Christiansburg, Va.—Until Feb. 15, by George W. Wilson, Clerk County Supervisors, for remodeling County Court House here.

Winnipeg, Man.—Until noon, Mar. 10, by Commissioners of the Transcontinental Ry., P. E. Ryan, Secretary, Ottawa, Ont., for the construction and erection, complete, of shops east of Winnipeg. Plans, etc., at the office of Hugh D. Lumsden, Chief Engineer, Ottawa, Ont., and S. R. Poulin, District Engineer, Winnipeg, Man.

Roads and Streets.

Bids are asked on following work, the notes being arranged alphabetically by states:

Chicago, Ill.—Until 11 a. m., Feb. 17, by Board of Local Improvements, Charles A. V. Standish, Secretary, for one contract for paving with limestone and granite, two contracts for paving with blast furnace slag and limestone, 19 contracts for paving with asphalt on concrete.

Chicago, Ill.—Until 11 a. m., Feb. 15, by Board Local Improvements, C. A. V. Standish, Secretary, for 52 contracts for constructing cement sidewalks.

Boonville, Ind.—Until 6:30 p. m., Feb. 16, by A. J. Batteiger, City Clerk, for constructing brick sidewalk, with cinder foundation, on 3rd St.

Danville, Ind.—Until 10 a. m., Mar. 1, by Wm. H. Nichols, County Auditor, for construction of three roads, 14,752, 12,983 and 51,236 ft. in length.

Indianapolis, Ind.—Until 10 a. m., Feb. 12, by Board of Public Works for the improvement of first alley east of Meridian St., by grading, graveling and rolling the roadway.

Liberty, Ind.—Until 2 p. m., Mar. 1, by Clinton Gardner, County Auditor, for constructing gravel road in Union Township.

Vevay, Ind.—Until 1 p. m., Mar. 1, by Scott Culbertson, County Auditor, for constructing three-mile gravel road in York Township.

Wabash, Ind.—Until 1:30 p. m., Mar. 2, by J. P. Noftzger, County Auditor, for improvement of a public highway.

Wabash, Ind.—Until 10 a. m., Mar. 4, by J. P. Noftzger, County Auditor, for grading, draining and graveling public highway.

St. Paul, Minn.—Until 2 p. m., Feb. 15, by Board Public Works, R. L. Gorman, Clerk, for curbing, etc., on Beacon Ave.

Brooklyn, N. Y.—Until 11 a. m., Feb. 17, by Bird S. Coler, Borough President, for the improvement of several streets by regulating, grading, curbing and paving with asphalt on a concrete base. Bids are also asked for laying sidewalks on a number of streets.

Corning, N. Y.—Until 7:30 p. m., Mar. 4, by Board Public Works, R. H. Canfield, Superintendent, for constructing about 3,600 sq. yds. brick pavement with cement curb and gutter and for 4,300 sq. yds. of macadam pavement.

Cleveland, O.—Until 11 a. m., Feb. 17, by for grading, draining and improving State Road No. 6.

Toledo, O.—Until noon, Feb. 16, by Board Public Service, Reynold Voit, Secretary, for paving portions of several streets with vitrified paving blocks, sheet asphalt or creosoted wood blocks.

College Hill (P. O. Beaver Falls), Pa.—Until 8 p. m., Feb. 19, by Town Council, Carl S. Donaldson, Borough Engineer, Beaver Falls, for improvement of College Ave., the work including 9,000 sq. yds. vitrified block paving and 2,800 lin. ft. of 20 to 36-in. storm sewer.

Philadelphia, Pa.—Until noon, Feb. 15, by Department Public Works, Geo. R. Stearns, Director, for repaving Market St., from Delaware Ave. to Bridge over Schuylkill River with selected Eastern granite blocks, best quality of refined natural asphalt or wood blocks. Specifications, etc., at office of Bureau of Highways, room 232, City Hall.

Waukesha, Wis.—Until 2 p. m., Feb. 26, by Board Public Works, John P. Dey, Chairman, for street improvement work to cost about $40,000 and to include 10,000 cu. yds. of excavation 18,000 lin. ft. of combination curb and gutter and 26,000 sq. yds. of macadam with tar surface. Official advertisement will be found elsewhere in this issue.

Sewers.

Bids are asked on following work, the notes being arranged alphabetically by states:

New London, Conn.—Until noon, Mar. 1, by W. H. Richards, Engineer Water and Sewer Commissioners, for constructing and laying a submerged wooden outfall sewer and settling basin and laying tile pipe connections.

Indianapolis, Ind.—Until 10 a. m., Feb. 12, by Board of Public Works, for the construction of a local sewer in first alley north of Indiana Ave., and other alleys, from Crawfordsville Road to alley south of 18th St.

Louisville, Ky.—Until noon, Feb. 26, by the Commissioners of Sewerage, J. B. F. Breed, Chief Engineer, Equitable Bldg., for the construction of 12th St. sewer, Contract No. 25. The work will consist, mainly, of building a reinforced concrete sewer about 3,900 ft. long, from 16 ft. to 27 ft. deep, and including about 3,350 cu. yds. of concrete and 320,000 lbs. of steel.

Natchitoches, La.—Until noon, Feb. 22, by P. E. Prudhomme, President Police Jury, for material and labor for constructing sewer from jail and court house.

King's Park, N. Y.—Until 3 p. m., Feb. 24, State Commission in Lunacy, T. E. McGarr, Secretary, Albany, N. Y., for sewerage and sewage disposal works, and alterations to plumbing wards 41, 42, 43, 44, 47, 48 and 49; plumbing and construction at the Kings Park State Hospital, Kings Park, N. Y. Certified check for $2,000 required with bid for sewer work, and for $500 for plumbing and alterations. Franklin B. Ware, State Architect, Albany, N. Y. Plans, etc., are also on file at office of State Commission, room 5212, 1 Madison Ave., New York.

Rochester, N. Y.—Until 3 p. m., Feb. 24, by State Commission in Lunacy, T. E. McGarr, Secretary, Albany, N. Y., for sewer and ejector at Rochester State Hospital, Rochester, N. Y. Franklin B. Ware, State Architect, Albany, N. Y.

College Hill (P. O. Beaver Falls), Pa.—See under Bids Asked—Roads and Streets.

Water Supply.

Bids are asked on following work, the notes being arranged alphabetically by states:

Colfax, Ill.—Until 7:30 p. m., Feb. 20, by J. C. Barnes, Village Clerk, for constructing water works. J. G. Melluish, Engineer, Bloomington, Ill. Official advertisement will be found elsewhere in this issue.

Decatur, Ill.—Until Feb. 19, by Albert Leach, City Clerk, for furnishing masonry work and piping for the new city water works pumping station. Daniel W. Mead, Engineer, 401 State St., Madison, Wis.

Rock Island, Ill.—Until 5 p. m., Mar. 1, by M. T. Rodgren, City Clark, for the construction of a complete mechanical filtration plant, bidder to furnish detail plans and specifications.

Elkhart, Ind.—Until 10 a. m., Feb. 17, by Board of Public Works for supplying the city and inhabitants with water for all domestic purposes and public uses, including fire protection, for a period of 25 years from April 28, 1909.

Fort Assiniboine, Mont.—Until 11 a. m., Mar. 4, by J. E. Sawyer, Chief Q. M., St. Paul, Minn., for the construction of a 150,000-gallon steel water tank and trestle at Fort Assiniboine, Mont.

Cincinnati, O.—Until noon, Feb. 12, by Board Public Service, John J. Wenner, Clerk, for furnishing labor and materials for the laying of pipe, special castings and valves, and other miscellaneous work in connection therewith, for the water distribution system of the city during the year 1909.

Milwaukee, Wis.—Until 10:30 a. m., Mar. 1, by Board Public Works, Charles J. Poetsch, Chairman, for furnishing materials and labor required to lay a cast iron water main 36 ins. in diameter across the Milwaukee River, from the foot of Bradford Ave. to the west side in extension of Wright St. Certified check for $1,300 required with bid. Bids are also asked for materials and labor required to lay a 36-in. cast iron water supply main in and along Terrace Ave.; certified check for $5,000 required with bid.

Milwaukee, Wis.—Until 10:30 a. m., Feb. 15, by Board Public Works, Charles J. Poetsch, Chairman, for furnishing materials and labor required to lay water mains in such streets in the city as may be directed by the Board of Public Works during 1909.

Miscellaneous.

Bids are asked on following work, the notes being arranged alphabetically by states:

Tiburon, Cal.—Coal Shed.—Until Mar. 1, by Bureau of Equipment, Navy Department, Washington, D. C., for constructing a coal shed at U. S. Naval Coal Depot, California City Point.

Savannah, Ga.—Dike Work.—Until noon, Mar. 5, by Col. Dan C. Kingman, U. S. Engrs., for raising and repairing dikes and training walls in Savannah Harbor, Ga.

Indianapolis, Ind.—Wire Fence.—Until 10 a. m., Feb. 11, by Board of Park Commissioners, for constructing 5,000 ft. of woven wire fencing.

Des Moines, Ia.—Electric Plant.—Until noon, Mar. 1, by Harry B. Frease, County Auditor, for an electric light and power plant for the County Court House and Jail. Proudfoot & Bird, Architects, 625 Flynn Bldg., Des Moines.

Albany, N. Y.—Rebuilding Fire Engine.—Until 3 p. m., Feb. 15, by Isidore Wachsman, Secretary Board of Control, for rebuilding steamer engine No. 6.

Milwaukee, Wis.—Hauling.—Until 10:30 a. m., Feb. 15, by Board Public Works, Charles J. Poetsch, Chairman, for hauling and delivering water pipe, hydrants and special castings as may be required by the Water Department of the city during 1909.

Ottawa, Ont.—Grand Stand.—Until noon, Feb. 12, by Central Canada Exhibition Association, 26 Sparks St., Ottawa, for the erection of a reinforced concrete grand stand on the Ottawa fair grounds.

Excavation, Earth and Rock.

Bids are asked on following work, the notes being arranged alphabetically by states:

Paw Paw, Ill.—Ditch Work.—Until 2 p. m., Feb. 13, by John Harper, Secretary Drainage Commissioners, for constructing main ditch and lateral, about three miles in all. S. T. Armstrong, Engineer, Sycamore, Ill.

Lebanon, Ind.—Ditch.—Until 10 a. m., Feb. 13, by Daniel Honan, Superintendent of Construction, at office of County Surveyor at Lebanon, for the construction of the Richardson public ditch.

Valparaiso, Ind.—Tile Ditch.—Until 10 a. m., Feb. 15, by Thomas J. Wilson, Construction Commissioner, at office of County Surveyor, for the construction of the Alpen 10-in. tile ditch, 2,561 ft. long.

Alexandria, Minn.—Ditch.—Until 10 a. m., Feb. 19, by E. J. Brandt, County Auditor, for constructing Judicial Ditch No. 2, requiring 116,000 cu. yds. of excavation.

Buffalo, N. Y.—River Improvement.—Until 11 a. m., Mar. 5, by F. G. Ward, Commissioner of Public Works, for the improvement of Buffalo River, the work requiring about 2,325,000 cu. yds. of earth excavation. Geo. H. Norton is Deputy Engineer Commissioner.

Materials, Machines, Supplies, Etc.

Bids are asked on following work, the notes being arranged alphabetically by states:

Chicago, Ill.—Cable.—Until 11 a. m., Feb. 13, by William Carroll, City Electrician, Room 403, 76 Fifth Ave., for furnishing 1,520 ft., more or less, 3-conductor, paper-insulated No. 00 lead-incased cable; 150 ft. more or less, single-conductor [illegible]-insulated No. 00 lead-incased cable.

Portland, Me.—Mooring Stones.—Until noon, Mar. 17, by the Lighthouse Inspector, Portland, Me., for furnishing mooring stones for the First Lighthouse District for the fiscal year ending June 30, 1910.

Baltimore, Ind.—Cement, Stone, Etc.—Until 11 a. m., Feb. 17, by Charles E. Phelps, Jr., Chief Engineer, Electrical Commission, for furnishing cement, sand, crushed stone, gravel, brick, lumber, and for hauling bulk material.

Boston, Mass.—Water Pipe.—Until noon Feb. 12, by Wm. E. Hannan, Water Commissioner, 58 City Hall, for furnishing 2,7[illegible] tons of cast iron pipes and special castings.

Grand Rapids, Mich.—Stone.—Until 3 p. m., Mar. 5, by Col. M. B. Adams, U. S. Engr., 57 Park St., Grand Rapids, Mich., for furnishing stone for pier filling at St. Joseph and South Haven Harbors, Mich.

Minneapolis, Minn.—Sewer and Paving Brick, Etc.—Until 7:30 p. m., Feb. 12, by City Clerk, for furnishing 2,000,000 sewer brick, sewer pipe, 200 tons of special castings, etc. Bids are also asked for furnishing 40,000 sq. yds. of paving blocks, 40,000 sq. yds. of vitrified paving blocks, 2,000 cu. yds. of crushed granite, 2,000 lin. ft. of 5x20-in. granite curb, 2,000 lin. ft. of sandstone curb, 150,000 sq. yds. of creosoted blocks. Bids are also asked for furnishing 40,000 bbls. of Portland cement for street work, 10,000 bbls. Portland cement and 5,000 bbls. natural cement for sewer work. Andrew Rinker, City Engineer.

Virginia, Minn.—Fire Hose.—Until 8 p. m., Feb. 16, by A. E. Bickford, City Clerk, for 1,000 ft. of 2½-in. cotton, rubber-lined, fire hose.

Muskogee, Okla.—Pump.—Until Mar. 1, by Morgan Caraway, City Clerk, for a 4,000,000-gallon, crank, fly-wheel pump.

Pittsburg, Pa.—Filing Cases.—Until 10 a. m., Feb. 11, by Department Public Works, A. B. Shepherd, Director, for steel filing cases, gallery and book rack to be erected in the office of the Bureau of Surveys, City Hall.

Haskell, Tex.—Pumps, Pipe, Etc.—Until Feb. 15, by the Mayor and City Council for the purchase by city of all material necessary in the construction of a system of water works and sewers which will include return tubular boilers, duplex pumps, boiler feed pumps, heaters, cast iron pipe, hydrants and valves; also standard vitrified, salt-glazed sewer tile and fittings, manholes, frames and covers.

Sherman, Tex.—Pipe, Hydrants, Etc.—Until 7:30 p. m., Feb. 15, by City Secretary, for furnishing following material: 1,750 ft. 6-in. cast iron pipe, 2,100 ft. 4-in. cast iron pipe, 50 fire hydrants, etc.

Calgary, Alta.—Rails, Wire, Poles, Etc.—Until noon, Feb. 18, by H. E. Gillis, City Clerk, for furnishing the following: 397 long tons 80-lb. steel rails; 746 long tons 60-lb. steel rails, together with certain special work, also spikes, bonds, tie plates, angle irons, track bolts, ties, etc., 12 standard street railway cars, one street railway sprinkler, one street railway sweeper, steel span wire poles 30 ft. and 35 ft., three sections; cedar poles, 12.5 miles of 2/0 trolley wire, 10.2 miles of 3/0 feed wire, span wire, hangers, insulators and conical strain insulators, ears, cross-overs and trolley frogs.

Calgary, Alta.—Boilers, Generators.—Until noon, Feb. 18, by H. E. Gillis, City Clerk, for furnishing city with 3 water tube boilers equivalent to 1,000 h.p., with piping and induced draft system for 2,500 h. p., also 1 500-k.w. generator connected to a 750-h.p. high speed engine for railway system, with condenser, switchboard, etc.

Saskatoon, Sask.—Pumping Engine.—Until 8 p. m., Feb. 24, by J. H. Trusdale, Secretary-Treasurer, for furnishing and erecting a pumping engine of a capacity of 1,200 to 1,500 U. S. Gallons of a capacity of 1,2[illegible] Chipman, Chief Engineer, 103 Bay St., Toronto, Ont.

CONTRACTS LET.

The following contracts have been let recently:

Huntsville, Ala.—Building.—Ben Caldwell for erecting school building for the Butler Training School.

Mesa, Ariz.—Water Works.—American Light & Water Co., Kansas City, Mo., for constructing water works for this city.

DeQueen, Ark.—Water Works.—American Light & Water Co., Kansas City, Mo., for constructing water works for this city.

San Bernardino, Cal.—Bridge, Culverts.—McIntyre Cement Co., Riverside, Cal., at $4,817, for constructing bridge over Warm Creek. Same company was also awarded contract for constructing five concrete culverts over Town Creek.

San Bernardino, Cal.—Crosswalks.—E. R. Werdin & Co., Los Angeles, Cal., at $[illegible], for putting in crosswalks here.

Sacramento, Cal.—Street Improvement.—F. Lowery, for improving N St. from [illegible]th to [illegible] St.

Denver, Colo.—Irrigation Work.—S. R. Robinson & Son Contracting Co., Chemical Bldg., St. Louis, Mo., at $[illegible], for constructing reservoirs and 12[illegible] miles of canals for the Henrylyn Irrigation District.

Wilmington, Del.—Metal Work.—The [illegible] and Mfg. Co., Bloomsburg, Pa., at $10,[illegible], for the metal work for the superstructure of Miah Maull Shoal Light-Station, Delaware Bay. The other bids received on this work were as follows: Pusey & Jones Co., Wilmington, Del., $11,[illegible]; The Champion Iron Co., Canton, O., $12,125; Lynchburg Foundry Co., Lynchburg, Va., $14,5[illegible]; Atlanta Machine Works, Atlanta, Ga., $16,[illegible]; Glamorgan Pipe & Foundry Co., Lynchburg, Va., $26,20[illegible].

Gary, Ind.—Bridge.—E. H. Crowell, Crown Point, Ind., at $[illegible], for constructing bridge over Calumet River at Gary.

Lincoln, Ill.—Sewer.—Lynn R. Parker, at $2,[illegible], for constructing sewer in North Hamilton St.

Cedar Rapids, Ia.—Bridge.—Clinton Bridge & Iron Works, Clinton, Ia., at $[illegible], for constructing bridge over Indian Creek at 30th St. Bridge is to be 144 ft. long and 16 ft. wide, of steel with concrete floor. Other bids received on the work were: Bartlett & Kling, $7,405; Toledo Bridge Co., $6,250; Union Engineering Co., $[illegible]; F. J. Miller, $[illegible]; Cook Construction Co., $[illegible]; Cedar Construction Co., $[illegible]; Pan-American Bridge Co., $[illegible]; Milliard Bridge Co., $[illegible].

Eldora, Ia.—Warehouse.—Johnson & Nelson, Red Wing, Minn., for erection of $[illegible] warehouse for the Western Grocery Co.

Maquoketa, Ia.—Bridge.—Clinton Bridge & Iron Works, Clinton, Ia., for building bridge over Maquoketa River at Hard Scrabble, in Jones County.

Monmouth, Ill.—Electric Railway.—Pat Walsh Construction Co., Davenport, Ia., is reported to have the contract for the construction of the south division of Rock Island Southern Interurban line to Rock Island.

Paris, Ill.—Post Office.—G. [illegible], for constructing new post office building here.

Gary, Ind.—Sewer.—Nash & Dowdle, Gary, at $7,2[illegible], for constructing one district and three local sewers for this city. Other bids received were as follows: Shea & O'Shea, Hammond, $[illegible]; W. F. Brant, Hammond, $8,362; E. M. Scheflow, Gary, $9,4[illegible].

Chisholm, Minn.—City Hall.—G. E. Kreitz Co., Duluth, Minn., for erecting new $40,[illegible] city hall here.

Toledo, O.—Dry Dock.—A. Bentley & Sons, Toledo, for constructing concrete dry dock for Toledo Shipbuilding Co., to cost about $[illegible],000.

Akron, O.—Bridge Abutments.—Eph Hovey, at $1,011, for constructing abutments for the Ira bridge for county commissioners.

Niles, O.—Sewer Pipe.—Crescent Supply Co., Marietta, O., for furnishing city with sewer pipe.

Youngstown, O.—Sewers.—P. Dirio for constructing sewer in Walnut St., and Patrick Grady, for constructing sewer in [illegible] Ave.

Guthrie, Okla.—Bridge.—Canton Bridge Co., Canton, O., at $18,61[illegible], for constructing steel bridge over the Cimarron at Coyle for the county. Bridge is to be 7[illegible]0 ft. long with 16 ft. roadway. The piers are to be steel cylinder tubes filled with concrete.

Pack City (P. O. Knoxville), Tenn.—Sewers.—John L. O'Connor, at $14,[illegible], for constructing sewer.

Houston, Tex.—Sewer Connection.—[illegible] & Horton, at $1,021, for the South End sewer connection.

Midland, Tex.—Sewers, Water Works.—O'Neil Engineering Co., Dallas, Tex., for constructing sewers and water works for the city, to cost $1[illegible].

Walla Walla, Wash.—Bridge.—Puget Sound Bridge & Dredging Co., Seattle, Wash., for constructing the North Coast Ry. bridge over the Columbia River. The bridge will cost about $1,[illegible]0.

Superior, Wis.—Bridge Work.—Whitney Bros. and Fred Baxter, for the construction of the main part of the northerly approach to the Duluth-Superior bridge for the Soo R. R.

Veracruz, Mex.—Terminal Work.—See under Protected Work, Railroads.

PROJECTED WORK.

Bridges.

Items Arranged Alphabetically by States.

Phoenix, Ariz.—Congress is to be asked to make an appropriation for the construction by the Federal Government of a bridge over the Colorado River at Yuma.

Sacramento, Cal.—Measure is to come before the State Legislature providing for the building by the state of a suspension bridge over the Carquinez Straits, near the towns of Benicia and Port Costa. It is thought that the bridge will cost at least $7,000,000. N. Ellery, Sacramento, Cal., is State Engineer.

Lewiston, Idaho.—The Lewiston Commercial Club has formed a committee to organize a stock company for constructing a bridge over Clear Water River at Lewiston, Idaho.

Grangeville, Idaho.—Bill is to come before the State Legislature providing for a bridge over the Salmon River at Goff. The river is 240 ft. wide at this site.

Cambridge, Ill.—County Commissioners have passed resolution for the construction of a bridge over Rock River at Colona to cost $33,200.

South Bend, Ind.—County Commissioners have been petitioned to reconstruct the bridge over the St. Joseph River at Logan St.

Indianapolis, Ind.—Board of Public Works has directed Blaine H. Miller, City Engineer, to prepare plans for construction of a bridge over Pleasant Run at Emerson Ave. The bridge will be of concrete and will cost about $5,500.

Sioux City, Ia.—Various railroads interested have agreed upon plans and specifications for the viaduct to be constructed over the tracks at Wall St. As proposed, the viaduct will be of steel and its whole length will be about 1,500 ft., including approaches. It is to cost about $200,000. Plans for it were prepared by G. A. Casseday, Bridge Engineer of the Great Northern Ry., St. Paul, Minn.

Wichita, Kan.—County Commissioners have decided to build two bridges over the Rock River at the south corner of Valley Center Township.

Lansing, Mich.—City Council is considering the matter of erecting a new bridge on Cedar St., to cost about $30,000.

Wabash, Minn.—The County Commissioners have decided to build a new concrete bridge over Trout Brook.

Great Falls, Mont.—The Boston & Montana Co. has decided to rebuild the suspension bridge over the Missouri River connecting the smelter with the Townsite Co.'s powerhouse.

Kansas City, Kan.—A bill is before the State Legislature to authorize the Commissioners of Wyandotte County to remove, rebuild or replace any of the bridges over the Kaw River.

Asheville, N. C.—County Commissioners are considering issuing $50,000 of bonds for building a bridge over French Broad River.

Cleveland, O.—Special election will be held April 6 to vote on issuing $1,000,000 of bonds for repairing the Central and Superior viaducts.

Youngstown, O.—City officials, the Baltimore & Ohio R. R. and the Erie and Pennsylvania R. R.s have taken steps for the construction of a $200,000 viaduct at Spring Common. City Council has voted a $50,000 bond issue for the improvement. F. M. Lillie is City Engineer.

Coshocton, O.—County Commissioners have ordered a $325,000 bond issue for the building of two new bridges at this point. Of this amount $183,000 is for the Main St. bridge over the Muskingum and $122,000 for the 12th St. bridge over the Tuscarawas.

Columbus, O.—The City Council has directed Henry Maetzel, Engineer, to prepare plans for the erection of a viaduct at 3d St.

Portland, Ore.—City Council has adopted a resolution favoring the construction of a bridge over the Columbia River from a point on Patton Ave. in this city to Vancouver, Wash., and recommending the appointment of joint committees of the Oregon and Washington Legislatures to investigate the project.

Pittsburg, Pa.—The City Finance Committee has recommended to Council an ordinance for 11 additional employes in the Bureau of Construction to prepare plans for the proposed new bridge at a point over the Alleghany River. The bill provides for two Assistant Engineers, five draftsmen, two chainmen and one transitman. A. B. Sheppard is Director of Public Works.

Hearne, Tex.—This city is to build a wagon bridge over the Brazos River, near the West plantation. P. L. Brady is Mayor.

Chelan, Wash.—A bill is to come before the State Legislature providing for the building of a bridge over the Chelan River at Wooden Ave., to cost from $10,000 to $12,000, of which the town is to pay one-third.

Waukesha, Wis.—Plans and specifications for a new bridge over the river at Broadway have been completed by the Board of Public Works. It will be a two-span, reinforced concrete structure and will cost $5,500.

Toronto, Ont.—Plans are about completed and bids are to be asked soon for the construction of a bridge at Bathurst St. C. H. Rust is City Engineer.

Railroads.

Items Arranged Alphabetically by States.

Gould, Ark.—The Gould Southwestern Ry., completed a short time ago, is stated to be projecting an extension of the line into Cleveland County in order to connect with the Cotton Belt and Rock Island. The right-of-way for a portion of the distance has been secured. At present the road extends from Gould to Star City, a distance of 22 miles. S. G. McClelland, of Gould, Ark., is General Manager.

Little Rock, Ark.—The Zinc Belt R. R., mentioned in our last issue, proposes the construction of a road from the mouth of the Big Creek, in Marion County, for the purpose of developing mineral lands. The projected length is 30 miles. The directors of the road include W. H. Gore, W. L. Allen of Chicago, Ill., Frank Pace of Little Rock, Ark., and H. Wells, Yellville, Ark.

Wilmington, Cal.—Los Angeles Harbor Co., A. C. Bird, President, Los Angeles, Cal., is constructing a 5-mile line around the west basin at Wilmington.

Lakeport, Cal.—The Crater Lake Northern Ry. Co. has been incorporated with a capital stock of $1,000,000 and proposes to build a railroad from Lakeport, in Lake County, to Pieta, in Mendocino County. The directors are R. C. Burnett, Marion Becki, San Francisco, Cal., Edwin Schwab, R. M. Sims, Berkeley, Cal., and W. I. Brobeck.

Wichita, Kan.—Surveys are to be made for the proposed road from this place to Kingsley, Kan. Levi S. Smith, Kingsley, Kan., is interested.

New Orleans, La.—The Illinois Central R. R., A. S. Baldwin, Chief Engineer, Chicago, Ill., according to advices from this city, will begin work this spring on the construction of freight sheds to cost between $3,000,000 and $4,000,000. The buildings are to be erected on the property recently purchased by the Yazoo & Mississippi Valley R. R. between Poydras and Girard Sts. and Clayborne and the basin.

Alpena, Mich.—The Detroit & Mackinac Ry., H. S. Waterman, Chief Engineer, East Tawas, Mich., contemplates extending a branch line to Hillman early in the spring.

Quitman, Tex.—The Texas Short Line R. R., now operating between Hoyt and Grand Saline, is said to be planning to build a 9-mile extension from Quitman to Sulphur Springs. T. B. Meeks, Grand Saline, Tex., is General Manager.

Pecos, Tex.—Contracts are to be let by March 15 for the construction of the Pecos & Southern Ry., which projects a 45-mile line from Pecos to Davis Mountain by way of Baymorhea. M. L. Swinehart, Pecos, Tex., is Chief Engineer.

Mt. Pleasant, Tex.—Paris & Mt. Pleasant Ry. Co. will soon begin work on the construction of 40 miles of line. Ten miles of line already built out of Mt. Pleasant will be used by the company and the 40 miles will be additional. The capital stock of $750,000 has been subscribed. R. F. Scott, Paris, Tex., is President.

Quanah, Tex.—The Acme, Red River & Northern Ry. Co. has changed its name to the Quanah, Acme & Pacific Ry. Co. and the capital stock has been increased from $25,000 to $70,000. The company is planning a 50-mile extension beginning on the west line of Quanah into Cottle County and through Hardeman County. The road at present is 12 miles long. T. K. Hawkins, Quanah, Tex., is Secretary.

Cape Charles City, Va.—Work is to be begun shortly by the New York, Philadelphia & Norfolk R. R. on the construction of a new freight yard at this place. It is also understood that the company expects to soon resume double tracking. In connection with the work the bridges at Salisbury and Fruitland, Del., are to be filled in. J. G. Rodgers, Cape Charles City, Va., is Superintendent.

North Yakima, Wash.—Press reports state that the contract for 18 miles of roadbed between this city and Beverley has been let by the Priest Rapids R. R. Co. to a local contractor. The Priest Rapids R. R. is said to be connected with the Milwaukee. Offices are to be maintained in North Yakima for furnishing labor and supplies.

Milwaukee, Wis.—The Chicago & Northwestern Ry. Co., C. S. Hall, Engineer of Track Elevation, Chicago, Ill., will proceed at once with its track elevation and bridge building work on the South Side and in Bay View.

Vancouver, B. C.—D. C. Corbin, Spokane Wash., President and General Manager of the Spokane International R. R., will re-apply at the coming session of the British Columbia Legislature for a charter for a line from Crows Nest to the International Boundary. The proposed extension will be about 50 miles long and will follow the course of the Flat Head River from the present terminus of the line. E. G. Taber, Spokane, Wash., is Chief Engineer of the Spokane International Ry.

Edmonton, Alta.—It is understood that the Canadian Northern Ry., T. Turnbull, Assistant Chief Engineer, Winnipeg, Man., has made arrangements with the provincial government for the construction of three branch lines in Alberta. These include the line from Edmonton northwest to Fort Assiniboine on the Athabaska River and eventually to Peace River Crossing. Another line is projected from Strathcona to Calgary and the third line is to be built from a point near the eastern boundary near Edmonton and along the Saskatchewan River.

Winnipeg, Man.—The Canadian Pacific Ry., J. E. Schwitzer, Assistant Chief Engineer, Winnipeg, Man., is planning to build in 1909, 300 miles of additional line throughout west Canada. The most important line will be the one through Alberta, parallel with the Crows Nest line and east to Calgary. For these extensions $6,000,000 has been set aside. The company is also planning to electrify a system through the mountains, and with that end in view, water sites for power plants have been purchased in many places through British Columbia.

Vancouver, B. C.—Final surveys have been approved and over one-half of the right-of-way secured for a line which the Great Northern Ry. proposes to build in the early spring from the Victoria, Vancouver & Eastern Ry. east of the Cascade south through the Okamagan River valley to Wenatchee, a distance of about 160 miles. The proposed line connecting the Canada and American portions of the whole of the system will cost about $2,000,000. A. Stewart, Seattle, Wash., is Assistant Chief Engineer of the Great Northern Ry.

Vera Cruz, Mexico.—The Terminal Company of Vera Cruz has awarded contracts for terminal construction at this place to S. Pearson & Son, Ltd., and Compania Bancaria de Obras y Bienes Raices, of Mexico City. The contract of S. Pearson & Son includes the erection of two large custom warehouses, a bonded warehouse, office buildings, round houses and machine shops on the Porfirio Diaz pier. La Compania Bancaria will build a large union depot and a reinforced concrete foot bridge 370 meters in length to span the railroad yards, tool houses, coach sheds and many other buildings. The terminal company itself will construct the freight yards which are to have an approximate trackage of fifty kilometers. An expenditure of $8,000,000 will be made for the work. J. W. Richardson, Chief Engineer of the Terminal Company, will have direct supervision of all the work. S. Pearson & Son will be represented on the work at Vera Cruz by D. Coe, and the Compania Bancaria de Obras y Bienes Raices will be represented by Rafael Arozarena.

Electric Railways.

Items Arranged Alphabetically by States.

Yellville, Ark.—The local Commercial Club has appointed a committee, of which W. E. Layton is a member, to secure right-of-way through the city for an electric railway.

Texarkana, Ark.—A movement has been started here to build an interurban line from the Texarkana to Sherman, Tex. W. F. Little, promoter of the line through Corsicana and other Texas towns is behind the movement.

Claremont, Cal.—Citizens are raising funds for a proposed right-of-way to be given to a branch of the Pacific Electric Ry. which plans a line to extend from Upland to Ponoma through Claremont and North Ponoma. A branch will be operated in connection with the Ontario [illegible] Ry.

Alturas, Cal.—A. P. Crow, Los Angeles, and B. F. Lamp of Los Angeles have applied to the County Supervisors for a franchise for an electric railroad in Modoc County. They propose to build a road to [illegible] and other points. Work [illegible] to begin within [illegible] years.

Eldorado Springs, Colo. The Eldorado Springs Ry. Co. has been formed by W. W. Sleven, C. W. Clark and Frank Haley of Denver, Colo., and proposes to immediately construct an electric railway from the Springs up the mountain side on the north.

Montrose, Colo.—Eastern capitalists are securing right-of-way for an electric railway to traverse the entire Uncompahgre Valley, as well as the valley of the North Fork of the Gunnison. The line will run south from Montrose to Ouray, Colo., and north to Delta, continuing up the north fork of the Gunnison, Paonia and Hotchkiss. The line will be about 90 miles long. I. N. Pepper, Montrose, Colo., is interested.

Washington, D. C. The Washington, Baltimore & Annapolis Electric Co., a subsidiary company of the Washington, Baltimore & Annapolis Electric Ry. Co., has applied to Congress for a charter to lay tracks from 15th and H Sts. to the District line. George T. Bishop, Frank H. Grimm and George H. Craig, all of Cleveland, O., are interested.

Wallace, Idaho. The City Council has granted franchise for a street railway in this city to the promoters of the Spokane, Couer d'Alene Electric Ry. H. M. Thatcher, Spokane, Wash., A. J. Devlin, Wardner, Idaho, and H. P. Knight, Couer d'Alene, Idaho, are interested.

Canton, Ill.—The Illinois Central Electric R. R. is planning to extend its line to Norris in the early spring.

Galesburg, Ill.—The People's Traction Co., which has been operating a line between Galesburg and Abingdon, is stated to have completed arrangements for the extension of its line from Galesburg to Galva.

Sterling, Ill.—Surveys are to be started shortly for the proposed line of the Tri-City Northeastern Interurban Ry. Co. The road is projected to run from Watertown to Albany, with the possibility of further extending it to Morris and Sterling. J. W. Crowley, President of the People's Construction Co., Davenport, Ia., is interested.

Anderson, Ind. The City Council has granted Wallace B. Campbell a 2-year extension for the franchise for an electric interurban railroad, which he proposes to build from this city to Noblesville and Lebanon.

Burlington, Ia.—Surveys have been made for the 20-mile line of the Burlington-Bonaparte Interurban Ry. Co., of which J. A. Johnson, Bonaparte, Ia., is President. The road is to extend from Burlington to Fort Madison.

Red Oak, Ia.—Surveys for the proposed road of the Red Oak & Southwestern Interurban Co. have been completed. The road, as projected, runs from Red Oak to Des Moines, via Cumberland, Greenfield, Redfield and Adel. B. Schreiner, Des Moines, Ia., is engineer. The road will be about [illegible] miles long.

Ottumwa, Ia.—The Interurban Construction Co. has been formed here with a capital stock of $10,000. The company has been formed for the purpose of making a system of surveys to ascertain the best route for building an interurban to this city. T. D. Foster is President and W. T. Harper is Secretary.

Cherokee, Kan.—The Joplin-Pittsburg Ry. Co., J. J. Helm, President, 1st National Bank Bldg., Kansas City, Mo., has been granted a franchise for the construction of an electric line into this city.

Lawrence, Kan. Albert Emanuel and W. B. Sullivan of Dayton, O., are seeking a franchise here for putting in a local street railway system.

Kansas City, Kan.—The Kansas City & Olathe Electric Ry. Co. has been granted a franchise for the construction of an electric railway from the state line in Graystone County to the Junction Cemetery in Wyandotte County. The proposed line will be 7 miles long. The company also has a franchise to extend its line south.

Hattiesburg, Miss. The Hattiesburg Traction Co. is stated to have secured necessary funds for the completion of its car line and the erection of its power plant. Work is to be started at once, it is said.

Springfield, Mo.—W. H. Schreiber, Engineer, has completed detailed plans for the electric railway from Springfield to Nixa. The line, as planned, will be about 18 miles long.

St. Joseph, Mo. Project for the Missouri Valley Traction Co., which proposes to build [illegible] has been revived. H. G. K[illegible] of [illegible] is [illegible] of the project.

St. Louis, Mo.—The St. Louis & Suburban Ry. Co. [illegible] of the [illegible] the proposed [illegible] to the [illegible] Florissant.

Southport, N. Y.—The [illegible] Traction Co. of [illegible] N. Y. has been granted a franchise [illegible] through the town.

Greensboro, N. C.—[illegible] Public Service Co. [illegible] and controlled by [illegible] New York have bought the Greensboro [illegible] with [illegible] interurban [illegible] build lines between Greensboro, High Point and Winston-Salem.

Akron, O.—The Northern Ohio Traction & Light Co. is reported to [illegible] with the work of [illegible] and improving its [illegible].

Golden City, Mo. [illegible] the proposed [illegible] Golden City Electric Ry. are to be [illegible] April, it is said. The company was incorporated with a capital stock of $[illegible]. The line will be from Pawhuska [illegible] through Bartlesville, Miami, Joplin, Carthage, Golden City, Stockton, H[illegible], Climax Springs and Brazito to Jefferson City. The first section of the road to be constructed will be from Golden City northeast to Stockton, and from Golden City southeast to Carthage. W. S. P[illegible], Jefferson City, Mo., is President; [illegible] A. [illegible], Golden City, Mo., is General Manager, and W. S. Hawkins, Pawhuska, Okla., is Chief Engineer. The grades of the road will be under 1 per cent, and there will be no bad curves. There will be five large bridges and some smaller ones, also some trestle work.

Media, Pa.—Philadelphia & West Chester Traction Co. has asked right-of-way over certain streets in this city. The company plans to make Media one of the terminals of its line.

Waco, Tex. Franchise has been granted Max Elser and associates of New York to construct and operate an [illegible] road through certain streets in the city.

Edmunton, Alta. The [illegible] street railway company is planning a [illegible]-mile extension.

Sewers.

Items Arranged Alphabetically by States.

Imperial, Cal.—City will vote [illegible] issuing $40,000 of bonds for constructing a sewer system.

Mountain View, Cal. City has voted a $40,000 bond issue for constructing sewers.

Ocean Park, Cal.—An election is to be held to vote on a $[illegible] bond issue for building a [illegible]-ft. addition to the Venice breakwater to dispose of the city's sewage out into the ocean.

Atlanta, Ga. The City Bond Commission has recommended a bond issue of $1,[illegible]; of this sum $700,000 is for sewers, $[illegible] for water works and $[illegible] for schools.

Monroe, Ga.—City sewer system is to be installed here soon.

Newton, Ill.—[illegible] Harper, C. E., Belleville, Ill., is preparing plans for several miles of street paving and sewers for this city.

Moline, Ill.—City is to [illegible] for constructing sewers and water mains in the Sixth Ward District. The estimated cost is $11,000.

Anderson, Ind. City Engineer Dowling is working on plans for [illegible] Creek [illegible] into a sewer by [illegible] reinforced concrete [illegible] the water.

Indianapolis, Ind. [illegible] A. [illegible] Assistant City Engineer, is [illegible] for a number of sewers. [illegible] will be in Mill St. and will cost about [illegible]. Plans are also under way for a sewer in M[illegible] St. to cost about $[illegible].

Hutchinson, Kan.—City [illegible] plans for constructing several sewers [illegible]. T. G. [illegible] is City Engineer.

Washington, Kan.—City Council has approved plans for a $[illegible] sewer system.

Lexington, Ky.—$[illegible] has been [illegible] by the Board of Public Works for [illegible] water sewers.

Salem, Mass.—Mayor H[illegible] has recommended that a sewer system be built in the [illegible] Hill District of the city.

Taunton, Mass.—The Sewer Commissioners have asked an appropriation of $[illegible] for constructing lateral sewers.

North Adams, Mass.—City Engineer R. L. Gardner has recommended a small appro[illegible] [illegible] sewer [illegible].

Fenton, Mich.—The [illegible] Village [illegible] [illegible] constructing a sewer system.

Grand Rapids, Mich.—The Board of [illegible] [illegible] J. W. [illegible].

Ann Arbor, Mich.—[illegible] City Engineer [illegible].

River Rouge, Mich.—City Council [illegible].

Detroit, Mich.—[illegible] Commissioners [illegible] $[illegible] [illegible].

Butte, Mont.—[illegible].

Liberty, Mo.—[illegible].

Marshall, Mo.—[illegible] for [illegible] sewer [illegible].

Wymore, Neb.—M[illegible] & H[illegible] have [illegible] sewer [illegible] water.

Grand Forks, N. Dak.—The City [illegible] [illegible] Ave. [illegible] $[illegible] or $[illegible].

Cleveland, O.—Board of Public Service [illegible] Park and [illegible] Ave. [illegible] sewer [illegible].

Cincinnati, O.—[illegible] sewers in the territory between McMillan Ave. and [illegible] and between [illegible] St. and [illegible] Bridge.

Hartshorne, Okla.—[illegible] Tex., has estimated [illegible] for constructing sewers for this city [illegible] $[illegible].

York City, Pa.—[illegible] $[illegible] of bonds for [illegible] to the city sewer system.

Charleston, S. C.—An election [illegible] here for [illegible] of bonds for [illegible] the sewer system.

Binghampton, Tenn.—Election will be held Feb. 11 to vote on issuing $[illegible] of bonds for [illegible] sewers and water [illegible].

Austin, Tex.—Mayor [illegible] has started a movement for the extension of the sewer system in all parts of the city. The city sewer [illegible] is [illegible] by a private company.

Richmond, Va.—[illegible] the Council [illegible] for $[illegible] for the [illegible] [illegible] City Engineer.

Water Supply.

Items Arranged Alphabetically by States.

Auburn, Ala.—Water [illegible] President [illegible] the town.

Faundsale, Ala.—The town proposes to install water works and electric light plant. S. Stallworth is Town Clerk.

Graceville, Ala.—[illegible] $12,000 of bonds for installing water works and electric light plant.

Wilmington, Del.—The [illegible] Water Improvement Co. has been incorporated with a capital of $[illegible]. The incorporators are H. [illegible] and F. A. [illegible] of Philadelphia, and W[illegible] M. [illegible] of Wilmington.

Clearwater, Fla.—Plans will be ready about Feb. 11 for [illegible] water works and sewerage. [illegible], Louisville, Ky., is Engineer.

Liberal, Kan.—City is considering [illegible] municipal water works.

Baltimore, Md.—Plans have been completed for construction of [illegible] for fire prevention purposes. About $[illegible] will be expended by the Board of Fire Commissioners for the work. [illegible] is Engineer.

Detroit, Mich.—[illegible] Commissioners [illegible] $[illegible] appropriation [illegible] water [illegible].

Corinth, Miss.—City will issue $[illegible] of bonds for water works and sewerage improvements and extensions.

Forest City, N. C.—Steps have been taken to call an election to vote on issuing $25,000 of bonds for installing water works.

Grand Island, Neb.—City Council has decided to enlarge water mains in business part of city.

Wymore, Neb.—Citizens are considering proposition of Markle & Huston to furnish pure water and a system of sewage for that city. The proposition includes the pumping of pure water into a reservoir at a certain charge per gallon to the city.

Elmer, N. J.—Borough Council is to be petitioned to call special election to vote on issuing bonds for installing water works.

Newark, N. J.—The American Water Supply Co. has been incorporated with a capital stock of $400,000. The incorporators include Lawrence W. Luellen, Hugh Moore and Austin M. Pinkham.

Clarington, O.—City Council has passed ordinances granting franchises to the Clarington Water & Electric Co. to put in a system of water works.

Collinwood (P. O. Cleveland), O.—Election will be held Mar. 4 to vote on issuing $20,000 of bonds for extending the water works.

Hamilton, O.—Ordinance has been before Council to extend city water mains at a cost of $10,000.

Wooster, O.—Board Public Service is considering extending water mains at a cost of $2,000.

McAlester, Okla.—City has voted to issue $203,000 of bonds for public improvements. Of this amount $20,000 is for water extensions, $175,000 for sewers and $8,000 for jail. J. M. Gannaway is City Clerk. J. Phelan is City Engineer.

Binghamton, Tenn.—City will vote Feb. 11 on issuing $25,000 of bonds for laying water and sewer mains.

Childress, Tex.—Plans are being prepared by J. B. Hawley, C. E., Fort Worth, Tex., for securing new water supply for this city.

Dallas, Tex.—The City Commission will construct a 36 or 42-in. cast-iron conduit, to cost about $30,000, to replace the present wooden conduit. J. M. Bassett is Chief Engineer of water works.

Elgin, Tex.—City has voted to issue $30,000 of bonds for building water works.

Eagle Lake, Tex.—A. H. Koennecke, proprietor of the ice plant of this city, has purchased the water works and electric light plants.

Granger, Tex.—J. Mitchell Smith of Belton, Tex., is considering installing a system of water works at a cost of about $10,000.

Marlow, Tex.—City has voted to expend $8,000 for water works.

TRADE NOTES.

The Massillon Bridge & Structural Co., recently incorporated with a capital stock of $250,000, has purchased the bridge plant at Massillon, O., and will manufacture bridges and steel structures of all classes. The official staff of the company is as follows: H. A. Croxton, President; C. S. Davis, Vice-President and General Manager; Miles C. Bland, Chief Engineer; E. Rice, Secretary and Treasurer; C. D. Yost, Asst. Secretary and Treasurer; Robert M. Reay, Superintendent of Shops; Robert Sweed, Superintendent of Erection.

Mr. Croxton is President of the Massillon Iron & Steel Co., and is identified with other manufacturing industries at Massillon. Mr. Davis was 12 years Chief Engineer of the Massillon Bridge Co. and three years Chief Engineer of the Toledo-Massillon Bridge Co. Mr. Bland was Contracting Manager for the American Bridge Co. at Cleveland four years, and Contracting Engineer for the Pittsburgh Steel Construction Co. for one year. Mr. Rice was Plant Engineer for the Massillon Bridge Co., 12 years, and Plant Engineer for the Toledo-Massillon Bridge Co. three years. Mr. Reay has been Superintendent of the plant at Massillon for 30 years. Mr. Sweed had charge of the erection work for the Massillon Bridge Co. 26 years, and for the Toledo-Massillon Bridge Co. three years.

The Zeman Iron Works Co. has changed its corporate name to The Cleveland Iron Works Co. The company has its offices and factory at 6824 Union Ave., Cleveland. O. The company makes a specialty of structural and ornamental iron and wire work, and also manufactures the Owen excavating bucket. In our last issue the original name of the above company was erroneously given as the Leman Iron Works Co.

The various days at the coming cement show of the Cement Products Exhibition Co., to be held at the Coliseum, Chicago, Ill., have been designated as follows: Thursday evening, Feb. 18, souvenir night; Friday, Feb. 19, engineers' day; Saturday, Feb. 20, architects' day; Monday, Feb. 22, home builders' day; Tuesday, Feb. 23, contractors' day; Wednesday, Feb. 24, building investors' day.

The Pittsburgh Meter Co. has moved its Chicago office to 256 Madison St.

At the recent annual meeting of the American Sewer Pipe Co. in Jersey City the retiring board of directors was re-elected with the exception of O. C. Barber, retired, who was succeeded by A. S. McCombe. Mr. Barber has been a director since the organization of the company, but insisted upon being relieved this year, feeling that he desired to give up active work as far as possible. The board organized by electing George R. Hill, President; John L. Porter, Vice-President; W. F. Dunspaugh, First Vice-President, and A. S. McCombe, Secretary and Treasurer, all of whom, with the addition of F. B. Theiss, were elected members of the Executive Committee. Thomas D. Brown, who has been Secretary and Assistant Treasurer since the organization of the company, resigned at the last meeting of the directors to engage in another branch of the clay business, with offices in Pittsburg.

Warren Wood, of the Wood Drill Works, Paterson, N. J., and Robert J. Wood, manager of the Chicago branch, will leave the United States on Feb. 19th for a three weeks' visit to the Panama Canal Zone for the purpose of inspecting the work done by "Wood" Rock Drills, and upon their return the Wood Drill Works will publish a booklet containing valuable cost data and comparisons, with some interesting views along the Canal.

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WATER-WORKS.

Colfax, Ill.

Sealed bids will be received up to 7.30 p. m., February 20, 1909, addressed to the Village Clerk, Colfax, Illinois, for constructing a system of water-works in accordance with the plans and specifications therefor. Certified check, 10 per cent. Payment will be made in "Water Fund Certificates." Plans and specifications may be seen at the office of the "American Contactor," or Village Hall, Colfax, Illinois, or office of J. G. Melluish, Engineer, Bloomington, Illinois.

The Village reserves the right to reject any and all bids.

W. E. GOUDY, Mayor.
J. L. BARNES, Clerk.

STREET IMPROVEMENTS.

Waukesha, Wis.

The Board of Public Works of Waukesha, Wis., will receive bids, at their office, on Friday, February 26, 1909, at 2 o'clock p. m., for street improvement work, consisting approximately of 10,000 cu. yds. of excavation, 18,000 lineal feet of combination curb and gutter and 26,000 sq. yds. of macadam with tar surfacing. Estimated cost, $40,000. Plans and specifications on file at office of the Board.

JOHN P. DEY, Chairman.

CONCRETE SEWER.

Ashtabula, Ohio, Jan. 20, 1909.

Sealed bids will be received by the Board of Public Service of the city of Ashtabula, State of Ohio, at the office of said Board until 12 o'clock, noon, Tuesday, Feb. 16, 1909, for furnishing the necessary labor and materials for the improvement of West St. from Auger Ave. to Fred St., Fred St. from West St. to Haskell Ave., Haskell Ave. from Fred St. to Benefit St., Benefit St. from Haskell Ave. to Prospect St., Mills St. from Benefit St. to Hope St., Hope St. from Mills St. to Prospect St., by constructing a sewer therein, according to the plans and specifications on file in said office. The work includes approximately 1,372 lin. ft. 1'10"x2'9" concrete sewer, 3,020 lin. ft. of 1'8"x2'6" concrete sewer, 774 lin. ft. of 20" sewer, 2,154 lin. ft. of 15" sewer, 1,790 lin. ft. of 12" sewer, 30 manholes, and all other labor, material, branches and appurtenances, as shown by the plans and specifications, or required by said improvement.

Bidders are required to use the printed forms furnished by the city, which can be had on application at the office of said Board, and are directed to observe the "Instructions to Bidders" therein contained.

The right is reserved to reject any and all bids.

By order of the Board of Public Service.
A. J. RICHARDSON,
Clerk.

REPAIRING DIKES.—U. S. Engineer Office, Savannah, Ga., Feb. 4, 1909.—Sealed proposals for raising and repairing dikes and training walls in Savannah Harbor, Ga., will be received at this office until 12 m. (eastern standard time), March 5, 1909, and then publicly opened. Information on application. DAN C. KINGMAN, Col., Engrs.

PIER WORK.—U. S. Engineer Office, 57 Park Street, Grand Rapids, Mich., Feb. 3, 1909.—Sealed proposals for furnishing stone for pier filling at St. Joseph and South Haven Harbors, Michigan, will be received here until 3 p. m., March 5, 1909, and then publicly opened. Information furnished on application. M. B. ADAMS, Col., Engrs.

COURT HOUSE.

Newton, Iowa.

Sealed proposals will be received by the Board of Supervisors, Newton, Iowa, until 2 o'clock p. m. on the 18th day of February, 1909, for the erection and completion of a three-story Court House for Jasper County, plans and specifications for which are now on file at the office of the County Auditor. Plans and specifications can also be seen at the office of Proudfoot & Bird, architects, No. 625 Flynn Bldg., Des Moines, Iowa.

Bids will be received for the building complete, including heating, plumbing and electric work.

Certified check $5,000; bond 25 per cent of contract price.

The right is reserved to reject any or all bids.

FRANK SELLMAN, County Auditor.

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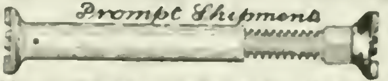

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REFUSE INCINERATION PLANT.

Milwaukee, Wis., Jan. 28, 1909.

Sealed proposals will be received at this office until Wednesday, March 31, 1909, at 10.30 o'clock a. m., for constructing and erecting at the foot of Erie street, in the Third Ward of the City of Milwaukee, a refuse incineration plant complete, with all appurtenances (except the superstructure of the building and the chimney above the foundations) according to plans and specifications on file in this office and also on file at the office of Hering & Fuller, consulting engineers, 170 Broadway, New York City.

The bidder must examine the plans and specifications for the superstructure of the plant and for the chimney (to be let in a separate contract) and agree that these are sufficient for and will in no way interfere with the fulfillment of his own contract and guarantees.

He must make a personal examination of the site of the proposed work and must also make such investigations as are necessary to determine the combustible character of the refuse to be burned, as now collected in the City of Milwaukee.

Bidders must state prices as set forth and directed in Section 1 B. of the specications, on specially printed blanks prepared for the purpose. Each bidder shall also prepare and submit with his proposal the drawings and statements enumerated in Section 1 B. of the specifications.

Work to be completed within one year from the date of the award of the contract, failing in which, the contractor shall pay to the City of Milwaukee, as liquidated damages, the sum of $500 per day for each and every day's delay in completing the contract.

Bonds to accompany bids required in the penal sum of $30,000, or in lieu thereof, the bidder may deposit with the Board of Public Works the sum of $15,000 in money or certified bank check. In case a bond is submitted, it must be signed by local bondsmen or by a surety company qualified to do business in the State of Wisconsin.

The blank form of the bond required, or the blank form for submitting money or check in lieu of the bond, will be furnished on application.

All moneys deposited will be returned to unsuccessful bidders on award of contract to and successful bidder when the contract is entered into.

The successful bidder will be required to enter into contract immediately after notification, with a bond for the performance of the work in a penal sum equal to the full amount of the bid for furnishing and erecting the plant.

Contractors desiring copies of the plans and specifications for their own use can secure the same from Hering & Fuller, consulting Engineers, 170 Broadway, New York City, on receipt of $15, as a guarantee for the safe return of said plans and specifications.

The Board of Public Works reserves the right to reject any or all bids.

CHARLES J. POETSCH,
J. P. SHERER,
L. A. JANSEN,
A. J. GRUNDMAN,
Commissioners of Public Works.
AUGUST M. GAWIN, Comptroller.

PIER WORK — U. S. ENGINEER Office, 57 Park St., Grand Rapids, Mich., Jan. 18, 1909.—Sealed proposals for repair of south pier at Frankfort, Mich., will be received here until 3 p. m., Feb. 16, 1909, and then publicly opened. Information on application. M. B. Adams, Col., Engrs.

FILTRATION PLANT.

Rock Island, Ill.

Sealed proposals will be received for the construction of a complete Mechanical Filtration Plant for the City of Rock Island, Illinois, in accordance with the plans and specifications on file in the office of the City Clerk on or before 5 p. m. March 1, 1909.

Detail plans and specifications must be furnished by the bidder. Bidders will comply with the general requirements of the specifications, but shall use their own detailed designs for equipment to be furnished, complete details of which must be submitted with bid.

Bidders must give evidence of their ability and experience in the construction of filtration plants and no bids will be entertained from parties not experienced in filter construction or unable to refer to plants in actual operation.

A certified check for 10 per cent of the bid must accompany each bid, made payable to the City Treasurer of Rock Island and to be forfeited to the City of Rock Island in the event of failure to enter into contract and give acceptable bond in the event of receiving award of contract.

Copies of plans and specifications may be obtained from the City Clerk on receipt of deposit of $50 for each set.

Bids must be made on the form of proposal furnished by the city and enclosed in a sealed envelope addressed to the Mayor and Council of Rock Island, Illinois, and have endorsed on one end the name and address of bidders.

The city reserves the right to reject any or all bids or accept that which may be deemed for the best interests of the city.

M. T. RUDGREN, City Clerk.

SEWAGE DISPOSAL WORKS.

Kings Park, N. Y.

Sealed proposals for Sewerage and Sewage Disposal Works, and Alterations to Plumbing, Wards 41, 42, 43, 44, 47, 48 and 49, Plumbing and Construction, at the Kings Park State Hospital, Kings Park, N. Y., will be received by the State Commission in Lunacy at the Capitol, Albany, N. Y., up to 3 o'clock p. m., on February 24, 1909, when they will be opened and read publicly.

Proposals shall be accompanied by certified checks in the sum of $2,000 for sewerage and sewage disposal works, $500 for alterations to plumbing, and the contractors to whom the awards are made will be required to furnish surety company's bonds in the sum of $20,000 for sewerage and sewage disposal works, and $3,000 for alterations to plumbing. The right is reserved to reject any and all bids.

Drawings and specifications may be consulted and blank forms of proposal obtained at the Kings Park State Hospital, Kings Park, N. Y., also at the office of the State Commission in Lunacy, No. 1 Madison avenue, Room No. [illegible], New York City, and at the office of the State Architect. Complete sets of plans and specifications will be furnished to prospective bidders upon reasonable notice to and in the discretion of the State Architect, Franklin B. Ware, Albany, N. Y.

Albany, N. Y., Feb. 1, 1909.

T. E. McGARR,
Secretary State Commission in Lunacy.

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Entered as second-class matter, April 17, 1907, at the Post Office at Chicago, Illinois, under act of March 3d, 1879.

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Why Congress Should Send a Committee to Panama to Investigate the Enormous Cost Under Government Day Labor Forces.

The visit of Mr. Taft with a commission of seven engineers to Panama, and the debates in Congress, have served to focus attention upon the enormously high cost of the work as it is now being done. Curiously enough Congress appears not as yet to understand the underlying reason for the great cost of excavation at Panama. Now that it is conceded that the actual cost of the lock type of canal will exceed the original estimate of the cost of a sea level canal, certain members of Congress are demanding that a sea level canal be built. Apparently they reason that it is the locks that are adding to the cost, or that in some mysterious way the high level canal has developed a high cost that would not occur in a sea level canal.

The facts are, however, that a sea level canal built at the present cost per cubic yard of excavation would run up to some $400,000,000 or more. Congressmen have yet to appreciate that it is costing more per cubic yard to excavate *earth* on the Panama Canal than it is costing to excavate the hardest of *rock* on the Barge Canal in New York state. When they do realize this fact, perhaps they will wake up to the necessity of sending a congressional committee to investigate not the type of canal but the reasons for the outrageously high cost per cubic yard of excavation at Panama.

Of course such a committee will be told all about the "great differences in conditions" at Panama and in New York state, but we wish to point out in advance the one real difference—the work at Panama is being done by government day labor forces, while the work on the Barge Canal is being done by contract at fixed unit prices. The story of nearly all the difference in cost of excavation on these two enormous canal jobs is told in the difference of policy of doing the work.

Never in the history of America has government day labor work been efficient on large public works construction, and the Panama Canal is proving this generalization with a vengeance.

The engineers who made the original estimate of the cost of the Panama Canal are now being condemned for their grossly inadequate estimate, but the fact is that those engineers had been assured by many large contractors that the unit prices for excavation, etc., upon which their estimates were based, were too high rather than too low. Those engineers certainly never dreamed that the government would attempt to do the work with its own forces instead of by contract, else they would have been fools to have submitted any estimate at all. In their report they used the most emphatic language in asserting that their estimate was exceedingly liberal, as indeed it was, had contracts been let at competitive prices to the lowest responsible bidder.

No sooner, however, had the work begun than the chief engineer decided to win all the glory of doing the work without the assistance of any of the [illegible] big contracting firms, as MacArthur Bros., Winston & Co., J. G. White & Co., W. J. Oliver, the Atlantic, Gulf and Pacific Co., and others that have done great excavation works. No, the chief engineer would "save the contractor's profits" and incidentally reap all the glory. One chief engineer has followed another, not one of whom was ever a contractor or a contractor's engineer, and the "contractor's profits have been saved" until the government is fairly reeking with money thus sweated out of its hard working laborers on the isthmus.

They are "hard working," for Mr Roosevelt found them so two years ago, and Mr. Taft found them so again the other day, and of course they must have been working hard all the time between, because the officials in charge say so. Mr. Taft saw evidences of "great energy" all along the line—enough probably to last until some one else makes another visit from Washington a year hence.

But, energy or no energy, the cost per cubic yard mounts higher each year, although it started at what seemed to be a peak load originally.

Congress should send not only a committee to Panama, but it should send also a number of engineers and contractors who are recognized authorities in construction economics. In no other way will the full folly of doing this canal work by day labor forces be made clear to the public.

In its issue of Dec. 2 Engineering-Contracting gave an analysis of the costs of construction at Panama, which was the first published demonstration of the fact that the Panama Canal is certain to cost 50 to 100 per cent more than the original estimate, if the present day labor method of doing the work is persisted in. Now we are beginning to be told that it was known years ago by the canal engineers that the original estimate was inadequate. If so, why in the name of common sense was that fact not made public in their annual reports? Instead the reports have held out the hope that unit costs of excavation would be "lower next year," and the records of cost have been so published as to make it very difficult for any one but an expert to tell what the ultimate cost of the canal would probably be.

We take some satisfaction in knowing that the correctness of our analysis (Dec. 2, 1908, page 365) has been admitted, for now the period of pipe dreams about the cost of the canal is past, and the public can see, what every experienced engineer has predicted, that the attempt to build the Panama Canal by day labor instead of by contract will end in a financial loss to America that will prove astounding.

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Construction Economics in Concrete and Re-inforced Concrete.

Construction economics have occupied a prominent place during the last twelve months in the study of concrete and reinforced concrete. We believe this to be the most important feature in the year's development of our knowledge of these two materials of construction. In putting forward this opinion we do not forget the studies of the year that have advanced the science of designing in concrete, nor do we purpose to detract one iota from their value and interest. The opinion is based on what we believe is the fundamental fact that the success of concrete as a structural material depends more on the practical ability of the builder than it does upon the technical skill of the designer. The two qualities should of course go hand in hand to get the very best that is to be got out of the material, but if either has to be made secondary we may better sacrifice nicety of design than construction skill and ability.

It is an axiom of concrete work that no degree of excellence in design can make up for incompetent, careless or ignorant work in construction. The reasons for this truth have been stated so often that they are known to everybody. Good concrete work can be obtained only by good work in construction. To compete with the older building materials not only is good work in concrete necessary but concrete work that is as cheap as or cheaper than cut stone, brick, tile, steel and timber construction. The fact that concrete is highly fireproof, that it grows harder and stronger with age, and, therefore, cuts maintenance charges to the minimum, and each of the half-dozen other advantages claimed for concrete has played a part in advancing the progress of concrete construction in public favor, but all of these facts together would not have put concrete in its present stage of popularity had it not been able to compete in cheapness with the product of the steel mill, the forest and the brick yard.

Continued success in concrete construction must come not alone from good concrete work but from good concrete work done cheaply, and it is to this pre-eminent fact that recent studies in the economics of concrete construction owe their importance. Let us observe further here that the significant value of these studies does not rest wholly in the specific data made known; the state of mind indicated, the general disposition to give construction economics place and consideration, is exceedingly valuable in possibilities. It is not so important that a number of concrete constructors have spread before us their methods of doing work and its cost, as it is that concrete constructors everywhere are enthusiastically in mind to study these questions.

There is today greater opportunity for and wider value in investigations in the field of construction economics than in any other field of concrete work.

Concrete and Reinforced Concrete Section

Note:—This section is devoted to methods and cost of constructing concrete and reinforced concrete structures. It will cover the selection, testing and proportioning of concrete materials; laboratory tests of concrete; concrete mixing, transportation and placing; fabrication and placing of reinforcement, and form construction and erection. It will also contain articles on new and interesting developments in the design of reinforced concrete.

Reinforced Concrete Stock Pen Construction for the Union Stock Yards & Transit Co., Chicago. Ill.

The most notable undertaking in piece construction in reinforced concrete in the United States is the rebuilding of the wooden structures of the Union Stock Yards & Transit Co. These structures comprise platforms, pens, runways, trestles, bridges, buildings and minor utilities. They are being replaced gradually by plain and reinforced concrete, such work being planned for each year as the company feels able to undertake, but the whole work to be finished within the next four or five years. The main objects sought are permanence and reduction of maintenance expenses, freedom from fire hazards, and better sanitary conditions. The great novelty of the work is that it is almost entirely piece construction; that is, the members composing the various structures are molded separately and then erected in place just as would be corresponding steel or timber members.

In this article we give some details of the new platform and pen construction; in future issues we expect to give details of bridge work and building work. The distinctive feature of all classes of work is the piece construction, according to a system devised by Mr. Pierre Holmberg, Chief Engineer. The characteristics of the system itself are best explained in another connection, but the purposes of piece construction in general can be set down at once. It is believed that it has been demonstrated that piece construction costs less for the classes of structures for which it is being used than would monolithic concrete. Further it adapts itself better than would monolithic construction to the conditions, which are the necessity of replacing piecemeal timber structures now in use. In addition there is the advantage belonging to all piece work as compared with monolithic concrete, that the accuracy of fabrication and the soundness of each member is known before it is put in place in the structure.

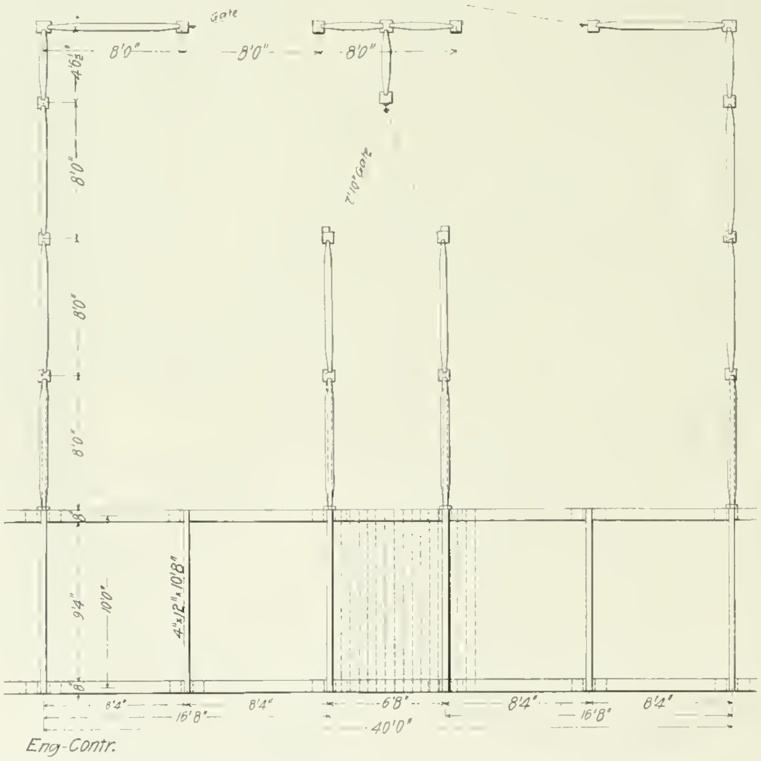


Fig. 1—Plan of Reinforced Concrete Stock Pen and Platform.

The new concrete pen construction can best be explained by the plans Figs. 1, 2 and 3. Referring to the plan Fig. 1, it will be seen that the pens are arranged side by side along an unloading platform with which each pen is connected by an inclined run. The platform, the retaining walls and the fences for the pens are all concrete. Fig. 2 is a section across the platform and platform fence showing the runway fence in elevation, and Fig. 3 is a front elevation of the platform and platform fence.

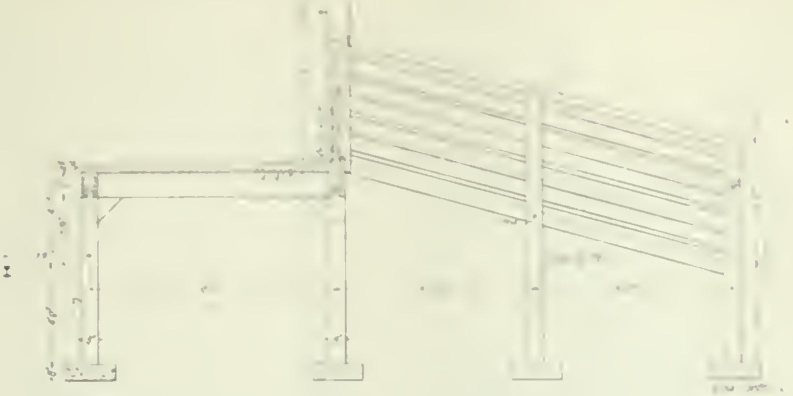


Fig. 2—Transverse Section of Reinforced Concrete Platform Showing Inclined Run.

Considering first the platform construction, Figs. 2 and 3 show it to consist of two rows of corbelled columns carrying longitudinal and transverse girders supporting a flat slab floor. The columns and girders are separately molded and then erected into place; the slabs may be molded separately and erected like the columns and girders or they may be molded in place. The column footings are molded in place in the pits with sockets to receive the bottoms of the columns, which are then erected and grouted into the sockets. It should be noticed that the columns are molded with corbels to take the girders and that the top of the column has a tongue or tenon to receive the girders. These are molded with a slot in the bottom face, this slot setting over the tenon on the column. The view Fig. 4 indicates the manner of this.

While the coring or slotting of the girders makes possible the mortice and tenon connection mentioned, this is not the only purpose of the coring. The theory is that the section of concrete represented by the slot serves no adequate purpose in a reinforced girder, and so by removing it there is no loss of strength and there is a saving in material and, what is far more important in piece construction, a material reduction in weight. The saving in weight runs from 20 to 40 per cent depending upon the size and character of the girder. The reinforcement for the slotted platform girders is clearly shown by Figs. 2 and 3.

To secure the advantage of continuity of girders over supports in this method of piece construction a special type of connection is employed. This connection is indicated by Fig. 3, but is better shown in a large scale detail in Fig. 5. As will be observed the ends of the abutting girders terminate over the column at a b and c d leaving an open space a b c d. In molding the girders the ends of the necessary reinforcing bars are left projecting beyond the ends of the girders and are bent to a hook. At e f it will be noticed that the end rods of the girders and their ends are [illegible] by f f, and [illegible] bear against the end faces of the corbels. When the girders have been set in place on the columns the hooked ends of tension bars are connected across the open space by drop forged turnbuckles which are drawn up tight. Then the mortise and tenon joint is grouted and the space a b c d is filled with concrete.

It will be observed from what has been said that Mr. Holmberg has arrived at a very simple solution of one of the annoying problems in piece construction for buildings, viz., continuity of girder action and rigidity of girder and column connections. No complicated mold work is necessary in casting girders or columns and the completing of the connection in the field involves only the most ordinary operations. The view Fig. 4 shows the erecting plant for the platform work, girders were being placed at the time the picture was taken. It may be said that this is a view of one of the first platforms built, and therefore does not represent structurally the more recent work. For example, the small corbels on the columns on which the cross girders rest as shown by Fig. 2 are not shown, nor is the girder connection just described. The view is however true so far as general methods of erection are concerned. The molded members are brought to the work in flat cars, from which they are picked up and handled into place by the derrick car.

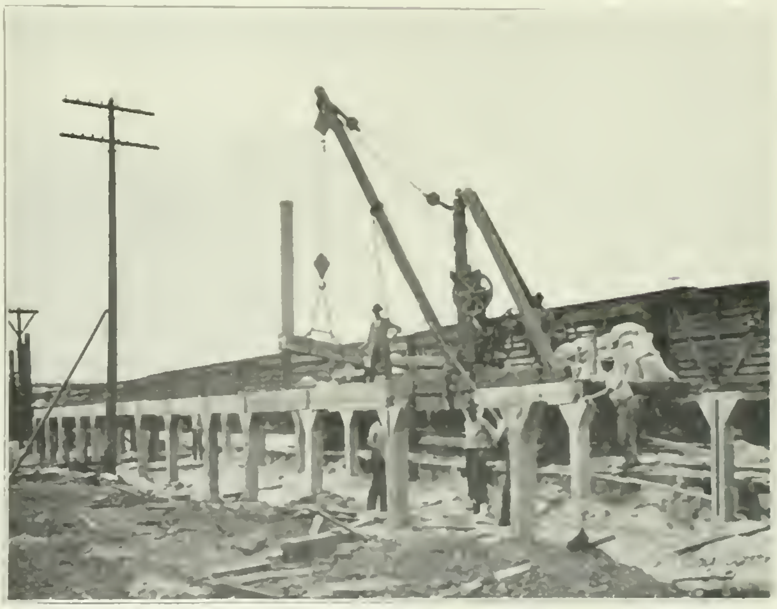


Fig. 4—Method of Erecting Reinforced Concrete Platform of Separately Molded Members.

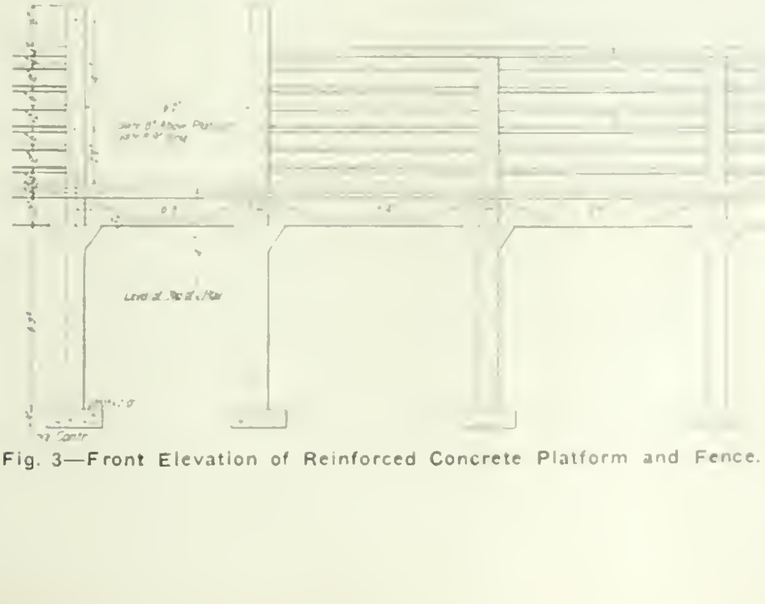


Fig. 3—Front Elevation of Reinforced Concrete Platform and Fence.

The slab work for the platforms calls

for only brief mention; it is clearly shown by Figs. 1 and 2.

The fence construction may be studied from Figs. 1, 2 and 3, and also in the view Fig. 6, showing one of the inclined runs. This fence consists of posts, "boards" and rail, all separately molded. The posts are H-shaped, or, rather, they have two sides slotted to receive the ends of the "boards." These are of I-beam section reinforced as shown, the flanges of the I being beveled down at the ends of the "board" so that it will enter the post slot. In erection the "boards" are slipped into the post slots, temporarily blocked apart vertically and finally grouted into the slots. The rail is a channel-shaped piece, which is placed, flanges down, over the tops of the posts and is grouted to the posts. The concrete walls holding the inclined fill for the runway and separating the pen from the space below the platform are shown by Fig. 6.

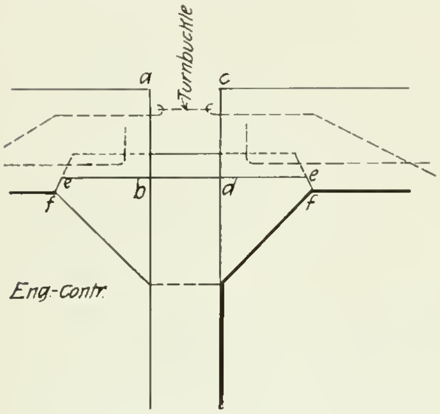


Fig. 5—Support of Girders Over Columns, Showing Connection.

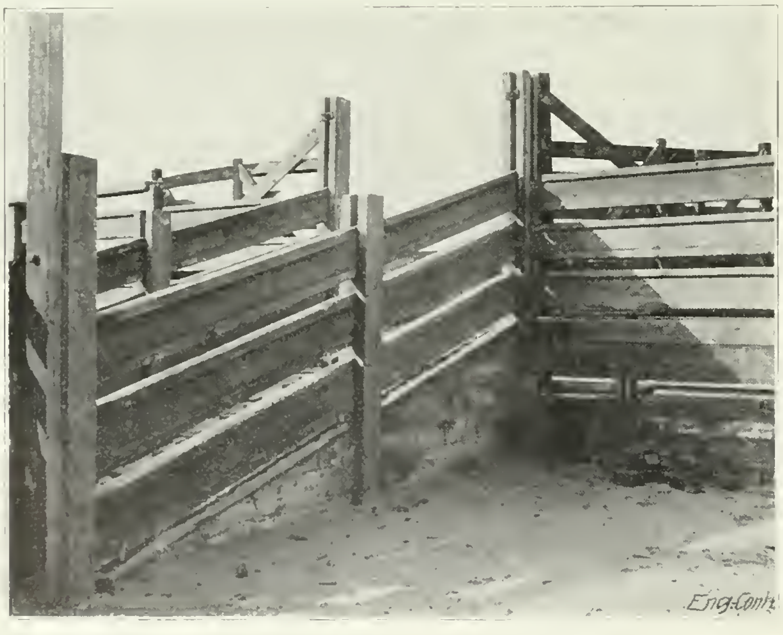


Fig. 6—View Showing Reinforced Concrete Fence.

The concrete used for all this work is a 1-2-4 Universal Portland cement and gravel mixture. No change in proportions is employed for pieces of different nature, but the size of the aggregate is varied from 1¼ ins. for the heavier pieces to about ¾ in. for the thin pieces. Until recently all the pieces were cast in wooden molds, but as the work becomes standardized metal molds are being made; the life of a wooden mold is not more than 20 pieces molded, no matter what care is taken of them or how well they are lubricated. A large molding plant is also being built—being now nearly finished—which is provided with means for handling mechanically the raw materials, mixed concrete and the molds and molded pieces. The molding house proper is a substantial wooden building, with a concrete molding floor, and is so piped for steam heat that a temperature of 120 F. can be maintained. It is the intention of Mr. Holmberg to utilize or at least to experiment with the use of high temperatures to hasten the setting and hardening of the molded pieces.

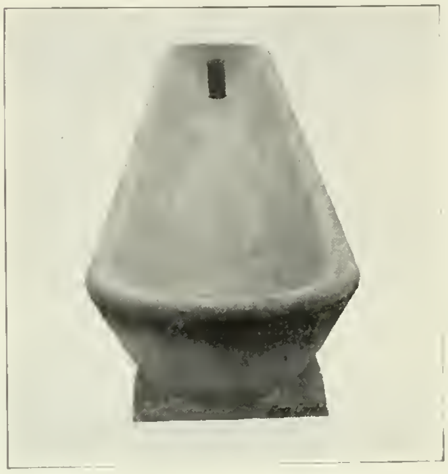
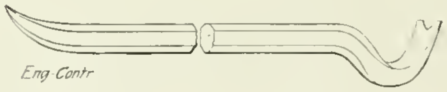


Fig. 7—Reinforced Concrete Watering Trough.

The stock pen and platform work described here is, as already stated, only one of several structural uses to be made of concrete in the "stock yards" reconstruction. Several large buildings and a number of bridges are now under way and will be described in future issues. It is not alone for large structures that concrete is being used, however. As an example of the smaller structures we show a concrete watering trough by Fig. 7. These troughs are reinforced with American Steel & Wire Co.'s triangular mesh and are molded in forms which are used over and over. The trough as shown has no special finish, but is just as it comes from the mold. No waterproofing material is used, but the concrete is proportioned to obtain a water-tight mixture. The curves of the trough sides are so formed that in freezing the ice slides up the sides and does not burst the trough. It is not so much in themselves, however, that these troughs are interesting as it is for the exemplification which they furnish of the extent and scope of the concrete construction which is rehabilitating the Chicago Stock Yards.

A Claw Bar for Removing Forms for Concrete Work.

Among the small tools required for carrying on reinforced concrete work none comes in more useful for a variety of purposes than a supply of crow bars, claw bars and chisel bars. As a rule such bars can be worked up on the job or by a local blacksmith from reinforcing material and need not be purchased at all. For chisel bars the steel need only be cut to length and sharpened to a chisel edge at one end. Bars so made can be used in an emergency for crow bars, and they have numerous uses such as chipping concrete, prying reinforcement into position, knocking out keys and spacers. Claw bars for removing forms and drawing nails can be made in the same manner. A good shape of claw bar for removing forms is shown by the accompanying sketch. This bar can be made of round or square iron as well as of the section sketched, and any ordinary blacksmith can do the work. Being made of reinforcing steel these various bars, if it is not desired to keep them, can, toward the end of the work, be used as reinforcement.



Claw Bar for Removing Forms.

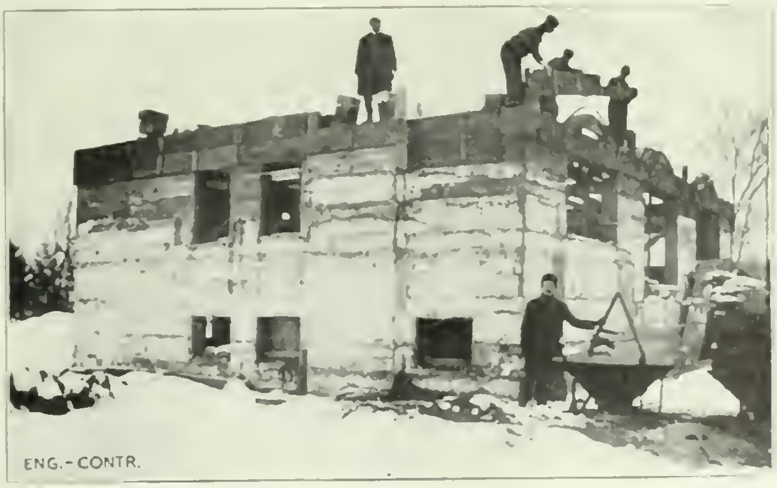
The Chicago, Milwaukee & St. Paul R. R. is planning, it is reported, the letting of contracts for the erection of two power-houses on the Missoula and St. Joe Rivers. The purpose of these plants is to generate power to operate the new Pacific coast extension through the Bitter Root mountains. This electrified section extends from St. Regis, Mont., to St. Joe, Idaho, and is 100 miles long.

A New Method of Using Forms for Building a Concrete House and Some Costs.

The cost of building houses of concrete is high, owing to the fact that the form work is quite expensive. Cost data on house building are meagre, but from records given in this journal and Gillette & Hill, "Concrete Construction, Methods and Cost," the cost of form work alone amounts to $3.50 or more per cu. yd. In most cases the cost of forms being nearly $5.00 per cu. yd. This means that on an average 45 per cent of the total cost of concrete in a house, is for form work.

The reasons for this are evident. A large amount of lumber has to be bought to make the forms and to be used as props to hold them. This lumber is seldom used more than three times on a building and often is used but twice. Carpenters have to frame and erect it, and frequently have to assist in taking down the forms. These things are bound to make the cost run high.

To overcome the excessive cost of forms a system known as the "Two Board Form Method" has been devised. The Dietrich Clamp Co. have originated this system and it is stated that it can only be used in connection with their clamps, the reason being that with these clamps the form boards can be removed while the concrete is still damp without interfering with the settling of the wet concrete. This method seems bound to play a very important part in reducing the cost of concrete work, and for that reason we give space to a detailed description of it.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House Being Built by Two-Board-Form Method.

The accompanying cut showing a dwelling house that has been built with the Two Board Form Method and the Dietrichs clamps in New Jersey. For this work the wall form clamp and the corner clamp are used. The wall form clamp has a hook head on it that hooks onto a loop of wire. The body of the clamp goes through the form boards and is held in place by means of the key. The wires are cut to the length needed and bent in advance.

The form boards are made of 2-in. plank, planed on two sides. These are strengthened with battens of 1½x3-in. strips, placed 30 ins. apart. Two ¾-in. auger holes are bored through the battens and planks to take the clamps. After the forms are made, either enough to go around the building, or around some section of it, if the structure covers a large area, they are given two coats of good metallic paint on both sides. As they are being used each time, the inside of the form is painted with a mixture of lard and kerosene, which prevents the cement from adhering to the forms.

After the foundations and footings are in place, the form boards are set up, the two sides being connected by the wires and clamps. Before lining up the forms some concrete is thrown into them at intervals, which gives some rigidity to the forms and keeps them in place when lined up. The forms are lined by by a mason's line and plumb and level, in a manner similar to bricklayers starting off a wall and carrying it to any desired height. As soon as the forms are in place and lined up, concrete is put in them all around the building. In the building illustrated, a Hain's Telescopic Mixer was used with a derrick to operate it. It was noticed that three men with a hoisting engine are doing all the work on this building.

The forms are so constructed that they are easily handled and need no braces or props to hold them. After they are made a carpenter is not needed. Only a few men are worked on the building, as the mixer is loaded from above, [illegible] serving into space, mixing the concrete as it goes through the mixer, and pouring it directly into the forms. This mixer and the system of forms thus do away with all unnecessary attention, such as erecting extensive forms, props and braces, also wheeling concrete in barrows and placing concrete, and a large number of men feeding the mixer are not needed. The water for the concrete is thrown into the two hopper shown in the illustration, before the derrick hoists the mixer. It is claimed that with the Hains Telescopic Mixer and the Dietrich system of forms only [illegible] is necessary to [illegible] down the labor needed in building a concrete house.

As soon as the concrete is brought up to the top of the two boards, the lower form board is taken down and placed on top of the second form board. This operation is being performed as shown in the photograph. It is possible to do this while the concrete is still damp, as the boards come off as easily as a door is opened, so that there is no drag, as with bolts, pipes, twisted wire and other form holders and separators to interfere with the set of the concrete. After the lower forms are raised to the top they are lined up as already explained. The operation of filling and raising the forms is continued until the building is completed.

It will be noticed that the window and door frames are all placed, as the house is built exactly as is done in building a brick house. Indeed, with the two-board form method all the work is done in a manner similar to brick work. If concrete floors are to be used the forms for the floors are placed as the walls are being built and when they reach the floor it is put in place, being monolithic with the walls. Then the second story walls are carried up. With this method a real monolithic structure is obtained, as the concrete is placed continuously and not once a week as is done when high and extensive form work is used.

To build the corners, the Dietrich's corner clamp is used on the outside of the form, while on the inside a small angle iron is used, to prevent the two boards meeting at the corner from binding when they are taken down. The operation is very simple.

The walls shown in the illustration are 8 ins. thick. The cost for all labor, including the labor of placing the forms as above described, of charging the mixer, of mixing and placing the concrete, in fact the entire cost of the concrete except for the materials, as stone, sand and cement, was 6 cts. per sq. ft. of wall, or $2.40 per cu. yd. of concrete, wages of the men being $1.50 for a 10-hr. day. This cost, as everyone familiar with building will know, is exceedingly low.

On a stable built in Philadelphia with the two-board form method and the Dietrich clamps, a great saving was effected on the forms. The lumber used in the forms and scaffolding was afterwards used in the roof of the building. The contractor, Mr. C. R. [illegible], stated that he saved 80 per cent of the ordinary cost of forms used for this class of work, and built a building of concrete for less than a brick structure or frame building could have been erected.

The Dietrich clamps are made by the Dietrich Clamp Co. of Little Ferry, N. J.

Method of Constructing Reinforced Concrete Pile Bents for the Atlantic City Boardwalk.

The boardwalk is Atlantic City's most widely known recreation feature, and undoubtedly it contributes more to the success of that resort than any other of its many attractions. Recognizing this fact, the city has spared neither trouble nor expense to make the boardwalk the finest structure of its kind in the world. As a result of this policy the walk has developed from an irregular, uneven plank walk, maintained by private individuals and subject to frequent washouts by the sea, into a broad, level promenade. Elevated above the reach of the tides, it stretches for miles along the ocean front and affords, both winter and summer, an unequaled place of recreation for hundreds of thousands of visitors.

In 1896 the greater part of the walk was rebuilt, steel piling and caps being substituted for the wood piles previously employed. The moist, salt air of Atlantic City corrodes iron or steel with amazing rapidity and the fine sand which drifts like snow in every wind forms a most effective sand blast in removing any protective coating of paint. In 1907 it was decided to relocate a section of the boardwalk, near the inlet, where the ocean had receded some 400 ft.

By the time the steel under the old boardwalk had become corroded to such an extent as to make its safety doubtful. In addition, the blistered and scaly appearance of the metal made the structure unsightly. Concrete had been used effectively for piling under some of the amusement piers, and therefore, from both practical and esthetic viewpoints, it appeared to those in charge of the work as the best material for the new construction.

Plans and specifications were drawn up by J. W. Hackney, city engineer, bids were invited, and in January, 1908, the contract was awarded to the Raymond Concrete Pile Co. of New York and Chicago.

STRUCTURAL DETAILS.

The piles were especially designed with a view to best meeting local conditions. As the boardwalk forms part of an architectural scheme for beautifying the city, it was essential that the piles be round and cylindrical, ornamental as well as useful. This factor precluded the use of the standard Raymond concrete pile, which is made by driving a tapered core within a sheet steel shell, withdrawing the core, and filling the shell with concrete.

As no reliance was placed on the frictional resistance of sand on the sides of the pile the base was enlarged to afford a greater bearing area. It then seemed probable, in consideration of the greater area of the base, that the sand would not settle closely under the foot of the pile after it had been jetted into place, causing subsequent settlement. While it is customary to drive piles to refusal after jetting is finished, in all cases where piling is driven into sand by means of a water jet, this obviously could not be done with a pile of the design used. It was therefore decided to prevent future settlement by compacting the sand under the pile, in the following manner:

A piece of 2½-in. pipe was cast into each pile, extending throughout its full length. The lower end was closed with a tapered wooden plug and the upper with waste to prevent the entrance of concrete. After the pile had been placed the plug was knocked out and sand rammed under the foot of the pile. As the pipe projected some 4 ins. beyond the top of the pile it likewise served in suspending the pile vertically in the pile driver leads.

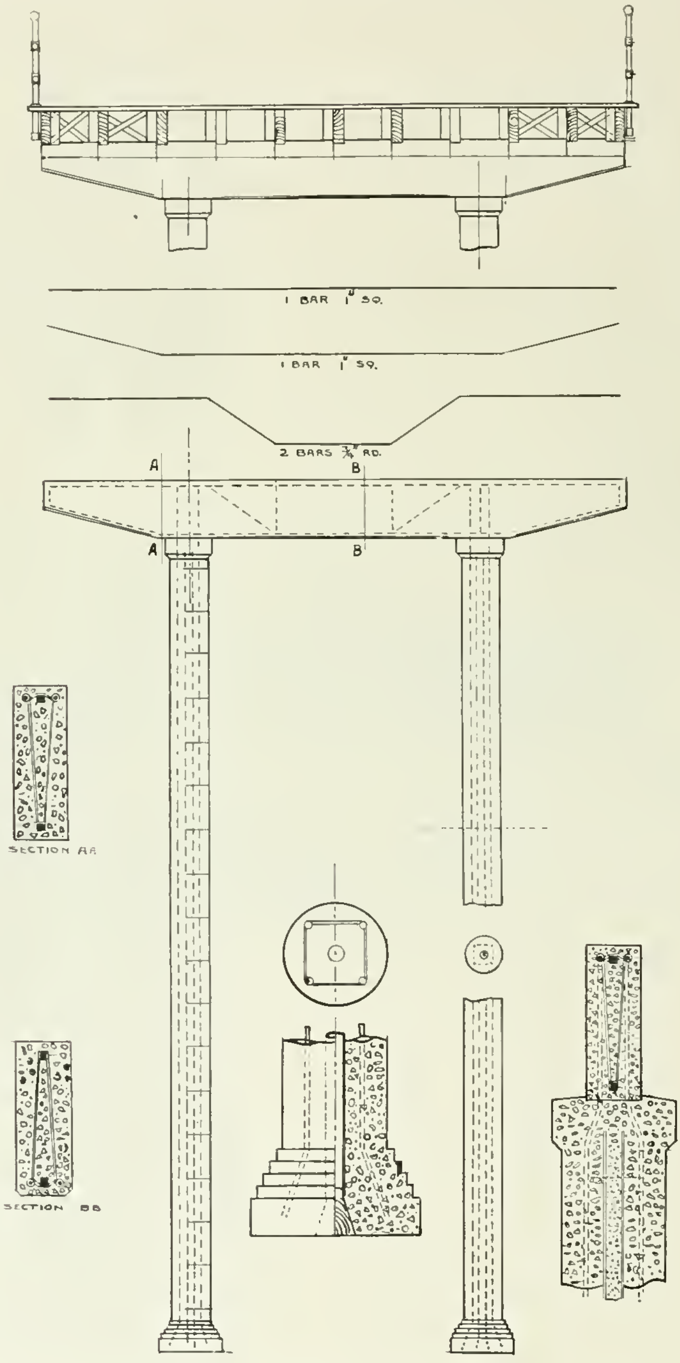


Fig. 1—Details of Piles, Girders and Platforms for Atlantic City Board Walk.

The piles were 16 ins. in diameter and of two lengths, 28 ft. and 32 ft., the shorter ones being used in the more protected portions of the walk and the longer ones in sections where the chances of erosion were greater. The elevation of the deck of the walk is 15 ft. above low mean water, the piles being driven 15 or 19 ft. into the sand, depending upon the location. This gives a depth in the sand of from 20 to 25 ft. and precludes any likelihood of the piles being disturbed by storms of the shifting of the beach from the action of wind and sea.

The walk is 45 ft. wide for a distance of 600 ft. and then narrows down to 21 ft. The wider section is supported on four pile bents, 20 ft. on centers, the piles being 10 ft. on centers, and the narrow section on two pile bents with the same spacing. The caps or girders are 8½x21 ins. in section, with a 5-ft. cantilever at each end. The design is simple, but the proportion and general effect are pleasing.

As reinforcement plain round or square rods were used throughout, the column reinforcing consisting of four ¾-in. round rods, hooped at intervals of 18 ins. with ¼-in. round iron. The 3½-in. pipe mentioned above, while not calculated as a part of the reinforcement, undoubtedly added much to the strength of the pile. The girders were reinforced with two 1-in. square rods and the two ¾-in. round rods. No stirrups were used. The rods of the columns projecting up into the girder for a distance of 18 ins. gave a good bond.

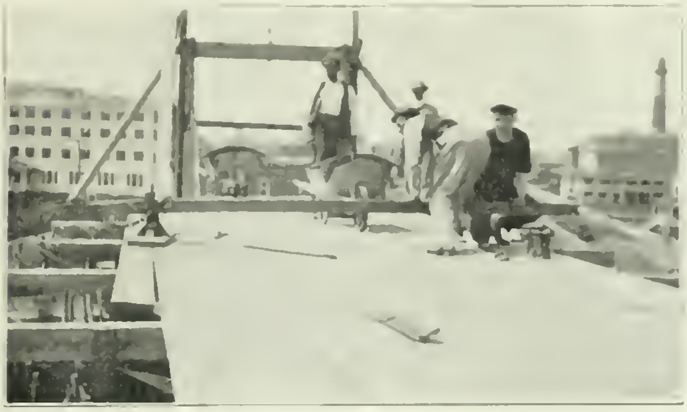


Fig. 2—Lever for Shifting Pile Molds from Space to Space Along Molding Trestle.

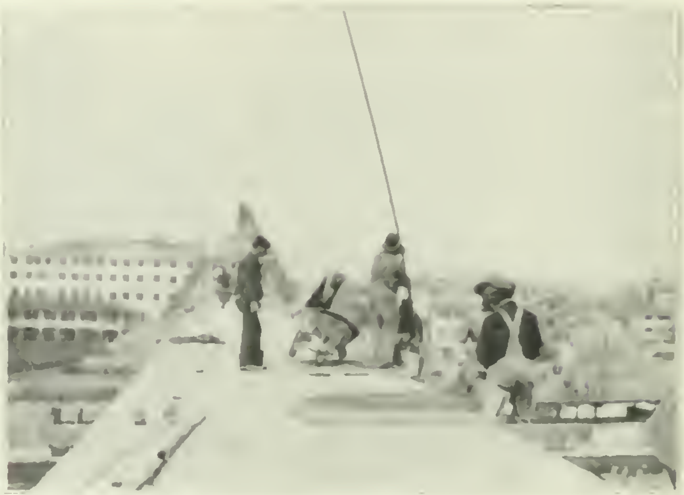


Fig. 4—Filling and Puddling Pile Molds.

The construction as described is shown clearly by Fig. 1.

CONSTRUCTION METHODS

The contractor's equipment consisted of a scaffold or trestle for casting the piles, a batch mixer, hoist, industrial railway and cars for moving the piles, pile driver and jetting apparatus and a force pump for supplying water to the jets. Nearly the whole line of the work was at or below high water mark and consequently subject to the effects of storms or high tides. On this account the contractor obtained permission to depart from the original specifications which contemplated molding and sinking the piles in sections at site. Each pile was therefore molded entire, off the line of work. In this way the use of a very satisfactory equipment was made possible and much better results were obtained. Due to the fact that each pile was cast entire and in one mold, joints and the danger of washed concrete from the chance admission of sea water were eliminated and a perfect alignment was obtained.

The construction work it will be seen may be separated into three processes: Molding the piles, sinking the piles, and molding the girders.

Molding Piles.—The piles were molded vertically, using a scaffold or trestle. The scaffold or trestle served as a bracing for the forms, a runway for distributing the concrete, and a substitute for a derrick or gin pole when lowering the piles. It was made of 16 bents, spaced 5 ft. on centers, and giving 15 spaces for molds on each side, a total of 90. It was 34 ft. high, 225 ft. long and 12 ft. wide, and was graded away from the hoisting end to facilitate wheeling. Guy ropes were carried from it to the ground at 40-ft. intervals on each side, giving great stiffness to the structure.

The molds proper were made of 16 gage sheet iron rolled into the proper cylindrical shape and screwed to wood braces. They were made in halves and bolted together with butt joints. Some difficulty was anticipated in handling the joints since they were 32 ft. in length, but by careful design and building in the first place and careful handling thereafter, no trouble whatever was experienced in putting them together or maintaining true alinement even after using some of them twelve times.

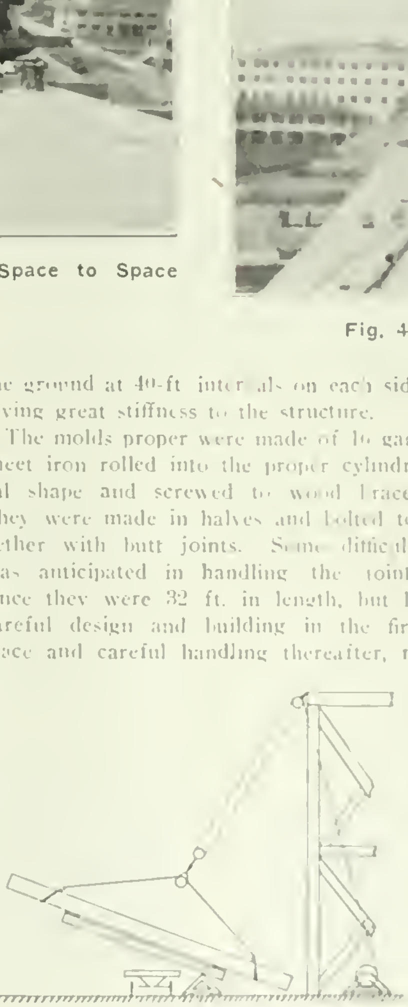


Fig. 3—Sketch Showing Method of Lowering Piles Onto Cars.

As stated above, there were 90 spaces along the scaffold for molds, 30 molds were employed, one for each third space. In rotation each mold occupied three different spaces, the cycle of procedure being as follows: When the first column could be stripped, generally in two to three days, the mold was removed and swung into the next space, recently greased, bolted together and filled. After two or three days this mold was again stripped, prepared as described and set up in the third space. By the time the third pile was ready to strip, from nine to ten days after the first was poured, the first pile was hard enough to be removed. The mold could then be swung back into the first space and the sequence of operations was repeated.

The molds were handled in an upright position, using a pivoted lever. Figure 2 shows the manner of using this lever. The short lever arm carried a chain and shackle which hooked into the top of the mold. Bearing down on the longer lever arm lifted the mold which was then swung to the next vacant space by rotating the lever on its pivot. This procedure was found capable and convenient.

To handle the cast piles was found a more difficult task. The piles were 28 and 32 ft. long and weighed some 3½ tons, and the reinforcement was not sufficient to keep the pile from breaking under its own handling weight. In fact when supported horizontally at two points half way between ends and middle the dead load stresses were far in excess of those considered safe. Some safe special method had to be devised for handling. The method adopted was as follows: Two rope slings were placed around the pile at points which would give the most even distribution of stresses, assuming the foot of the pile to be supported. To these slings was hooked a wire cable, with considerable slack, which passed through a snatch block. The snatch block was hooked to one end of a tackle, the other end of which was fastened to the top edge of the scaffold. The fall line from the tackle ran to a hand winch on the ground. A strain was taken on the tackle and the pile pushed out from the scaffold at the top until supported by the tackle, its bottom resting on a sill. The tackle was then backed off with the winch, the snatch block traveling along the bight in the sling cable as the pile approached the horizontal. As the pile neared a horizontal position it was received on a wooden cradle 16 ft. long with 2-in. pillow blocks at each end. This cradle was tipped back onto a flat car as the pile came to the horizontal, the slings were cast off, and cradle and pile were slewed around parallel with the car track which ran alongside the scaffold. The car took the pile to a storage yard, where it was rolled onto a skidway to cure. The sketch, Fig. 3, helps to explain the method of lowering the molded piles onto the cars.

The narrow gage railway on which the cars ran, passel along both sides of the scaffold by the storage yard and along the line of the walk. It proved to be a great labor saver. For moving the piles two platform cars were fitted with turn-tables, making it possible to swing a pile to any angle from the track. This was found necessary both to aid in loading the columns on the cars and in picking them up by the driver. A dump car was used to distribute material for the caps and girders. All lumber was moved on the flat cars.

The concrete was a 1-2-4 mixture of Alpha Portland cement, washed sand and screened ½-in. gravel. It was mixed in a ¼ cu. yd. Chicago mixer. The mixer was located at the highest end of the staging, with stock piles close by. The concrete was discharged into wheelbarrows and wheeled about 10 ft. to a wheelbarrow hoist at the end of the trestle. The top of this hoist is shown by Fig. 2. The hoist had room for two barrows, the wheeler running on a full and taking off an empty barrow each trip.

In filling the molds, great care was taken in mixing and depositing the concrete to insure freedom from voids and to obtain a smooth finish. To this end the amount of water in the mixture was varied as the mold was filled, the first mixture, at the bottom, being very wet, and succeeding batches dryer until no water showed when the top was reached. The careful construction of the molds made them practically water-tight and enabled this gaging to be done with accuracy. The concrete, after reaching the top of the scaffold, was not wheeled and dumped directly into the forms but was first turned out on a platform, Fig. 4, whence it was shoveled into the form thus ensuring a perfect mixture. During the process of filling the concrete was continuously puddled by means of rammers extending the entire depth of the column. As a result of these precautions not one of the 360 piles cast was found in any way defective.

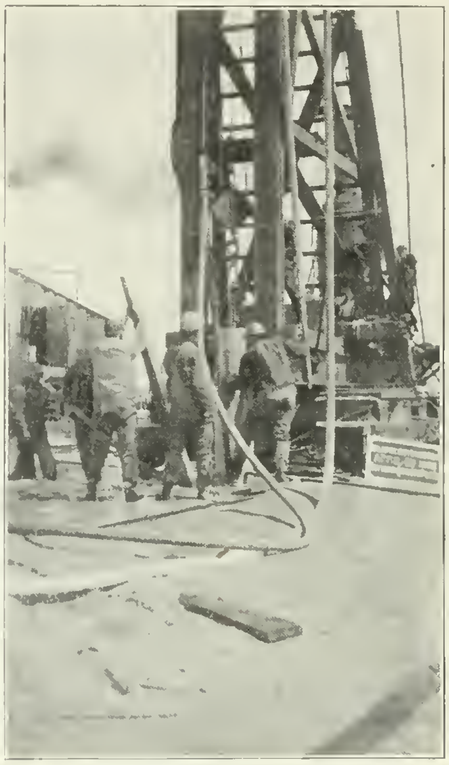


Fig. 5—Outfit for Jetting Piles.

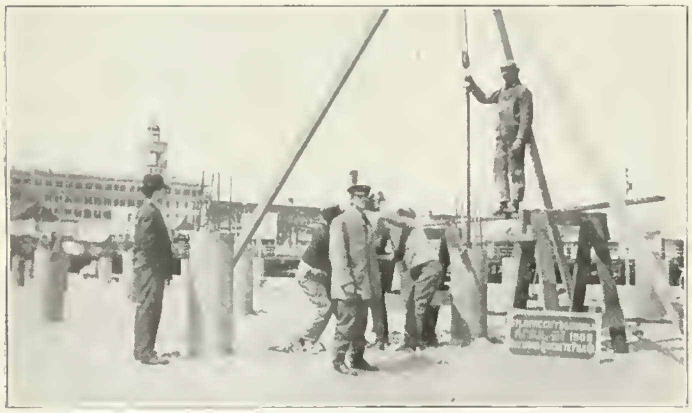


Fig. 6—Compacting Sand Under Foot of Piles.

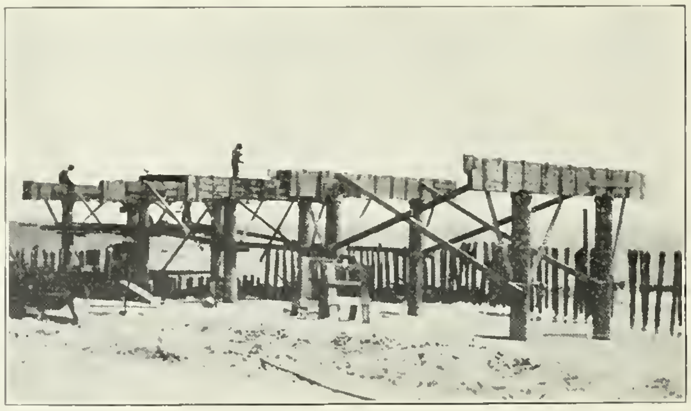


Fig. 7—Forms for Molding Girders.

Driving Piles.—The molded piles were driven or sunk by water yet using the standard Raymond driving outfit shown by Fig. 5. The procedure of the work was as follows:

The round pile was rolled off the storage skids onto the cradle and as previously described and was then run to the driver. Here the slings, cable and snatch block arrangement, and as before described to lower the piles from the scaffold, was adjusted and the pile up-ended using the main purchase of the pile driver in place of the block and tackle. When vertical a hanger was secured into the end of the pipe projecting from the top of the pile, the purchase was hooked into this hanger and the slings were cast off letting the pile hang vertical and free in the leads.

The driver was then swung to bring the pile over the stake and sinking was begun using two jets. The pile settled by its own weight through the sand, but when layers of clay were encountered it had to be churned until it broke through. When the pile had been sunk to the proper depth and in the proper position the jets were pulled allowing the sand to settle around the pile which it did in two or three minutes.

Forty-eight hours after jetting the piles were settled in the following manner. A piece of 2-in. shafting, 2 ft. longer than the pile, was introduced into the central pipe and alternately raised and dropped, knocking out the wooden plug and compacting the sand under the foot of the pile. This process was continued until the pile ceased to settle, from 2 to 6 ins. of settlement usually occurring. When no further settlement was perceptible the pipe was filled with concrete and a cap moulded on to the column to the exact grade required Figure 6 shows the apparatus used for compacting the sand under the foot of the pile.

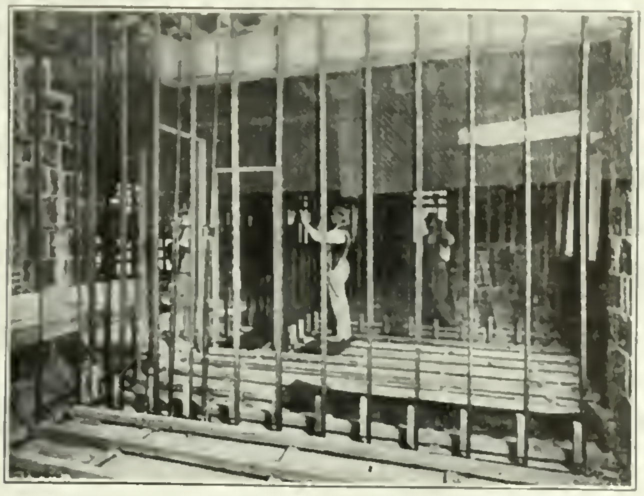
To supply water for the jetting a Worthington 8 and 12 by 7 by 10 compound pump and a 30 hp. boiler were set up in an old jetty on the beach and a suction line run out into the ocean. Water was delivered at about 100 lbs. pressure through a maximum of 1,100 ft. of pipe.

Molding Girders.—The method of molding the girders was simple and is clearly indicated by Fig. 7. Girder forms were set on top of the pile caps and braced as shown. The concrete was brought from the mixer to the work in dump cars.

For the information from which this description has been prepared we are indebted to Mr. Aldrich Durant, Superintendent of Construction, Raymond Concrete Pile Co., New York city.

Metal Lath and Steel Partition Construction.

Plastered cement and metal construction has a wide field of usefulness in construction work. It gives for walls and partitions a very light incombustible construction at moderate cost. In the accompanying cut we show a view of some partition construction of this type. This work is a portion of the several thousand square feet of partitions used in the large new Y. M. C. A. building at Indianapolis, Ind. All this partition consists of 1-in. Youngstown prong studs covered with Mahoning metal lath and plastered. About 110,000 lin. ft. of lath were used. The studding and lath were furnished and the partitions were erected by the Chicago Builders' Specialties Co., of Chicago, Ill., as constructors.



Metal Lath and Steel Partitions, Y. M. C. A. Building, Indianapolis, Ind.

Between 1,500,000 and 2,000,000 cu. yds. of rock will be used for the concrete work in the locks and dams at Miraflores and the locks at Pedro Miguel on the Isthmian Canal. The rock will be quarried from the south slope of Ancon Hill, and will be transported from the quarry by train to the crushers. The crusher plant will consist of one large and four auxiliary crushers. The large crusher will take pieces of rock as large as 36 by 36 ins. as they come from the quarry and reduce them to 5 ins. or less. This crusher can handle 100 cu. yds. of rock an hour. Such rock as comes from the quarry in pieces that will pass through a 5 in. ring, and the product of the big crusher, will be conveyed by gravity to the four auxiliary crushers, where it will be broken into pieces that will pass through a 2½ in. ring. From the auxiliary crushers the rock will be conveyed to cars on a siding now in process of construction whence it will be hauled to the works at Miraflores and Pedro Miguel. Power for running the crushers will be supplied from the electric power house at Miraflores.

Methods and Cost of Constructing Concrete Pedestals for a Steel Viaduct.*

The viaduct was 110 ft. long with towers 30 ft. high on the Canadian Northern Ontario Ry. The concrete work consisted of 10 x 10 x 4-ft. footings carrying pedestals 5 x 5 ft. on top with sides battered 1 in 12 to meet the footings. The tops of the pedestals were all at the same elevation but their height varied, the highest being 18 ft. above tops of footing. The pedestals were cored for anchor bolts. The total amount of concrete in the work was 711½ cu. yds., of which 298½ cu. yds. were in the footings and 405 cu. yds. were in the pedestals. The concrete was a 1-2½-4 mixture, taking 1 1/12 bbls. cement for the footings and a 1-2¼-4 mixture, taking 1¼ bbls. cement, for the pedestals. Altogether 3,350 bags of cement were used for the 711½ cu. yds. of concrete, including 11 bags for the 1-2 mortar top dressing and 15½ bags for washing, plastering, etc.

Excavation.—The pits for the footings were 12 ft. square carried down into hard clay through 5 or 6 ft. of sand and clay and a 1-ft. layer of driftwood. The average depth of pit was 11½ ft., the maximum depth 15.2 ft. The material was handled by a horsepower derrick, consisting of a guyed mast and a boom set at 45°. The bucket was lifted by a double-purchase block, the fall of the line being carried to a pulley set a few feet to one side of the mast and thence to a swingle tree. This gave enough side pull on the boom to swing the bucket clear of the excavation. To hold the boom fixed during hoisting and lowering [illegible] line [illegible] end carried to the far side of the excavation and operated by one man. One man drove the horse. Two ¾ cu. yd. buckets were employed, one being filled while the other was being dumped. There were 1127 cu. yds. of excavation, which cost as follows:

Item	Total	Per cu. yd.
General expenses	$194	$0.172
Foreman, 35 days at $3	105	0.093
Labor, 323 days at $1.60	517	0.458
Horse, 26 days at $2	52	0.046
Totals	$868	$0.769

Forms.—The forms for the footings were rough 2-in. lumber braced to the pit walls. The pedestal forms were made of 2-in. dressed lumber. Five sets were made. Each form was made 16 ft. high and was added to at the bottom for the taller pedestals and cut off for the shorter pedestals, which were built last. Two sides of each form were built in panels or units, and the two other sides were built up board by board as the concreting progressed. The solid panel sides were held together by two wire ties every 3 ft. in height; one tie every 3 ft. held the other two sides. These ties were No. 9 gage wire looped around studs and tightened by twisting. There were also core forms for the anchor bolts, each a box 4 ft. long, 6 ins. square on top and 5½ ins. square on the bottom. The cost of the forms was as follows:

Lumber:	Total	Per cu. yd.
7,000 ft. B. M. 2-in. derrick at $19 per M	$133	
2,000 ft. B. M. 2-in. rough at $18 per M	36	
750 ft. B. M. 2x4-in. scantling	14	
Cartage, $2.50 per M ft.	24	
Anchor bolt boxes, etc.	10	
Totals	$217	
Deduct salvage $10	$207	$0.29
Wire, Ties, Nails:		
5 rolls No. 9 at 3 cts.	$12	
200 lbs. wire nails at $2.50	5	
Totals	$17	$0.024
Labor:		
Carpenter, 28 days at $2.50	$70	
Helpers, 38 days at $1.75	67	
Totals	$137	$0.193
Grand totals	$361	$0.507

Concrete.—The concrete was mixed by hand on "boards" set close to the piers and was shoveled directly into the forms. The materials were transported to the boards in wheelbarrows. A gang of 1 foreman, 5 barrowmen, 6 mixers and 1 man in the form averaged 25½ cu. yds. per day, or a little over 2 cu. yds. per hour, working [illegible]. The maximum day's work was [illegible] cu. yds. [illegible] 10 min. The concrete was deposited moderately wet and the mortar was spaded to the surface. The top 3 ins. of the pedestals was built of 1-2 mortar. The exposed surface of the piers was washed with a thin cement grout. About 1 bag of cement was required for 75 sq. yds. of surface. One man washed 7½ sq. yds. per hour.

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*Re[illegible] by J. H. R[illegible] Jan. 2[illegible], 1909.

using an ordinary whitewash brush. The cost of the concrete work was as follows:

Materials:	Total.	Per cu. yd.
173 cu. yds. rubble stone at $0.85	$ 147	$0.207
555 cu. yds. 2-in. stone at $1.875	1,041	1.463
290 cu. yds. sand at $1.25	363	0.510
840 bbls. cement at $1.80	1,512	2.121
Cartage at 15 cts per bbl.	126	0.163
Totals	$3,190	$4.464
Labor:		
Foreman, 28 days at $4	$112	$0.157
Laborers, 343 days at 1.75	600	0.843
Totals	$712	$1.000

General. Expenses.—General expenses were as follows:

Superintendence	$239.50
General labor	78.40
Int. and Dep. on plant and tools	70.50
Total	$388.40

This gives a charge of 27.3 cts. per cubic yard of concrete.

There were also the following items of cost:

24 M ft. B. M. 6x8-in. hemlock at $20	$480
Shoring excavations 2500 ft. B. M. timber	57
Labor backfilling piers	162
Platforms, runways, etc	69
Total	$768

We can summarize the cost of concrete work as follows:

	Per cu. yd.
General expenses (½ of $388)	$0.273
Platforms, runways, etc	0.097
Forms	0.507
Labor	1.000
Materials	4.464
Total	$6.341

The Gunnison Tunnel of the Colorado-Uncompahgre Project was advanced 550 ft. during January. A considerable delay was caused by temporary increase in the flow of water at the river portal and by the necessity of timbering seamy ground in the heading. In spite of these difficulties, 200 ft. of advance were made in this portal. An advance of 350 ft. was made in the Cedar Creek portal, in which the material encountered continues to consist of comparatively dry granite of varying toughness. Concrete work was carried on in both headings throughout the month. The tunnel at Feb. 1 was 74.3 per cent completed.

The Vera Cruz Terminal Co., Ltd., has placed contracts for its railway terminals at Vera Cruz, Mexico. The terminals will cost about $8,000,000. The contractors are S. Pearson & Son, Ltd., City of Mexico, and Cia Bancaria de Obras y Bienes Raices, City of Mexico.

Earth and Rock Section

Note: This Section is devoted to methods and costs of excavating earth and rock and building embankments. It will cover the grading of roads and railroads, diking and canal work, dredging, building reservoirs and earth dams, sewer and water pipe trenching, quarrying, etc.

Comments on the Use of Wagons in Transporting Earth.

(Continued from p. 111, Feb. 10, 1909.)

One method of transporting material in construction work that is becoming more common each year, is with belt conveyors. For earth excavation belt conveyors have not as yet been used very extensively, but they have, during the past decade, been frequently employed for this purpose and under enough different conditions to demonstrate both their practicability and adaptability, especially when the distance over which the material is to be transported is fixed. Belt conveyors can be used for loading wagons.

For this purpose a platform can be built over the belt conveyor and scrapers can be used to excavate the earth, dumping on to the conveyor from the platform through a trap, and a hopper built under the platform. At the other end of the conveyor wagons can be used to catch the earth as it falls from the conveyors. A better arrangement for this purpose is to have the conveyor discharge into a bin and have the wagons loaded from the latter. This allows the belt conveyor to work continually. If a steam shovel or a grab bucket is used to excavate the earth, a movable hopper is constructed over the belt conveyor and the dipper of the shovel or the bucket is emptied into this hopper.

Belt conveyors can be used to load wagons in connection with the excavation of much earth-work, as cellars, the inside of reservoirs and other large pits. Where the excavated material is to be elevated to any great heighth, belt conveyors will do the work and save attendance, but the amount of material must be large enough so that the plant charge will not be excessive.

Another method of loading wagons is by means of a derrick skip that has both ends open. The skip is loaded by means of scrapers, and is then picked up by a derrick, cableway or a special machine for this purpose and dumped into the wagon. This method would also be adapted to cellar excavation and other earth work.

When wagon teams have to go up heavy grades, as from cellar excavations and deep pits, or even on hilly roads a snatch team should be used to assist the regular team. It must be remembered in all hauling, that the heaviest grade on the road or runway, sets the limit on the size of the load, hence in most hauling and especially in hauling excavated material, the use of a snatch team, means the increasing of the regular loads hauled, thus reducing the cost of transportation. Many contractors use a three-horse snatch team, and as a rule for wagon work such a team is better than two horses, but for most work, the writer prefers a four-horse snatch team, worked in two pairs. Such a team with a limited number of wagons means a larger load hauled without fatigue to the wagon team, and with a large number of wagons, it frequently happens that two wagons are loaded at about the same time, when the four-horse team can be divided into two snatch teams and the two loads are started to the dump without waste of time. Then, too, with a four-horse team, two of the horses can be used as a load team for the plow, having only two horses on the plow regularly. Four horses may be needed on the plow to break the ground for the first plowing, but the second time the material is plowed, only two horses need be used, dispensing with the load team, which can be again joined to the snatch team.

The four-horse snatch team is well adapted to do this kind of work when three horses are used on the wagons. Most contractors work only two horses on their wagons, and the writer believes that this is a mistake. Most of the coal dealers in our larger cities have learned that much better work is done by a three-horse team than with two, and to-day it is a common sight to see three horses hitched to a coal wagon. The same principle applies to a contractor's hauling. In keeping the records of many thousand loads of earth hauled in bottom wagons of 1½ and 2 cu. yd. capacity, it was found that the average load hauled with two horses was 1 cu. yd., place measurement. With three horses even with a 2 cu. yd. capacity wagon a load from 1¼ to 1½ cu. yd. could be hauled and on good roads or streets with a larger capacity wagon a larger load could be carried. The dead weight would remain nominally the same, the extra load being entirely of the material being hauled. The increased cost is the hire of an extra horse, or the expense of feeding and caring for this horse. Thus with the cost of a horse at $1.00 per day and a driver at $1.50 per day the cost of a three-horse team making an allowance of 25 cents for the wagon, is $4.75 against $3.75 for a two-horse team. Thus with a two-horse team, hauling 10 cu. yds. per day, at a cost of 37.5 cents per yard, a three-horse team will haul 15 cu. yds. at a cost of 31.7 cents per cu. yd.

Another important item in connection with hauling is the keeping up of the runways and roads. In earth excavation the neglect of the runway means to quickly increase the cost. Some years ago the writer made an experiment to obtain what effect this would have on the cost excavation. On two runways of less than 1,000 feet one of the runways was maintained in good condition for a month, while the second one did not have any work done on it. The excavation on the runway that was kept in order was done for 3 cents per cu. yd. less than the other.

Dump wagon manufacturers are building wagons to go over rough ground without upsetting or making it hard on the team, and this is necessary, for wagons frequently have to go over plowed ground and uneven places to be loaded or to get into the road or runway, but this is not an excuse to make them always go over rough ground.

If a large number of wagons are not being used over a runway, and the ground is neither very sandy or wet, it will be possible to keep up the road at a small cost, but under some conditions it is out of the question to attempt to maintain a dirt road under such circumstances, for a temporary road, boards can be laid down crossways and the wagons can travel over them. Unless the ground is very wet, or much rain falls, it is not necessary to lay down a stringer or sleeper to which the boards can be fastened, but the boards can be laid directly on the ground. Some kind of soft wood is better for this purpose than a hard wood, as with a soft fibrous wood, the boards quickly splinter on the exposed surface from the traffic, making a soft mat upon which a horse can obtain a good foothold in climbing a grade.

For longer roads, and especially a piece over which many wagons will travel for a long period of time, it is often advisable to build a regular macadam road. The metal roadbed need not be very wide as only the loaded teams will keep on the metal part of the road, the empty teams pulling out onto the dirt to pass. Such a macadam road need not be more than 8 or 10 feet wide. Such a road should be maintained in a first class condition.

Another method of constructing long runways that are to be used for some time is to lay down light channel bars of steel as a track for the wheel on each side of the wagon. This leaves a dirt path for the horse to walk upon, but a very large load can be easily carried on the wagon. Such tracks have been used very successfully. The channel must be well connected and at the joints it is generally necessary to support them in some manner.

One objection to the use of three horses on a wagon, is that extra room on the road or runway is needed for the third horse, and at times this does preclude the use of three horses, but in many cases there is ample space. This is so on streets. In city work it is nearly always possible to use a larger wagon than on country roads as the hauling power of a team is greater on smooth pavements than on rough roads. This is illustrated by the fact that for use in cities, wagons have been built with a capacity of 12 cu. yds. struck measure, to be drawn by three horses. Such a load could not be hauled by the same number of horses on work in the country. For city use wagons with springs on them means that the loads are carried over rough paving without spilling, and that much of the noise is eliminated. This is not so necessary for country work, yet springs of the proper kind on any wagon meant for heavy hauling, means that the load is not so racking to the running gear and also makes the draft of the wagon easier.

There is nothing more important in a wagon than a light and easy draft. Not only are springs an aid in this, but also a short wheel base, and well-fitting boxes in the wheels. In this connection the wheels should be lubricated with a good grade of grease or a lubricant that does not dry out quickly. A too rigid wagon tongue effects the draft of wagon, by interferring with the easy action of the horses, especially in pulling up a heavy grade. This is important likewise in using a snatch team. The snatch team should not, if it is possible to do otherwise, be hitched to the tongue of the wagon. If it is hooked to the tongue, it should not be to the end of the tongue, but to a ring fastened under the tongue a foot or so back from the front end. A better arrangement is to have a long rod fastened under the double tree, and run out under the tongue, being held up by a long link at the front of the tongue. The rod should be about 6 inches shorter than the tongue. It is a fact that these rods are easily broken, but they pay for themselves in the wear and tear saved the wagons and the greater ease with which the horses will do their work. A long chain under the tongue should not be used with a snatch team as it is very liable to injure the wheel horses. A snatch team should always be hitched as close to the wagon as possible.

The dumping of the wagon and the character of the dump upon which it is to be used is often the determining factor in deciding upon the type of wagon to be purchased. We have previously stated in this series of articles that for the convenience of considering them, we have divided wagons into three classes or types: (1) Bottom Dump, (2) End Dump, (3) Special Dump. The manufacturers of both of the two first classes claim that each type can do the same work done by the other type, and under some circumstances this is true, yet the experienced contractor knows that each class has its particular use. On flat embankments [illegible] the bottom dump wagon is generally used. The load being dumped while the wagon is in motion stretches the earth out over a space about one and a half times as long as the box of the wagon [illegible]. As a rule the earth must be spread out in layers either by means of men with shovels or by some kind of spreading machine. Bottom dump wagons are adapted to the building of such embankments, and most embankments can be built in this manner. But there are occasions when it is necessary to build embankments by end dumping from the finished grade of the bank, or by back dumping. For work of this character, end dump wagons are suited. However, the embankment must be wide enough for the team to turn on it, but with the front wheels turning under the wagon body a team can be turned within its own length.

In dumping on scows a bottom dump wagon can be used, but it is easier on the horses and the scow can be loaded better with an end dump wagon. Scows though are sometimes loaded by means of chutes and platforms when it is not possible to drive the wagon onto the scow. For this purpose an end dump wagon is suited, as it can be backed up to a chute and the load dumped directly into it, while with a bottom dump, the platform must be built out over the chute and the load dumped into a trap. This means that either the angle of the chute must be flattened or else an expensive framework must be built out over the deck beyond the wharf or pier line. In dumping through traps either bottom or end dump wagons can be used. Likewise when trestles are used to dump from, either type of wagon can be used.

When material is to be placed in stock piles, either end or bottom dump wagons can be used when it is possible to take the wagon on top of the stock pile. When this is not feasible, other methods for handling the material must be employed. One is to dump into a hopper or bin from which a conveyor, of some style, takes the material, elevating it and delivering it into the pile. Or the load can be dumped into a skip and then dumped onto the pile with a derrick or cableway. To facilitate such work there has been invented several styles of special dump wagons.

One of these is the invention of George Perrine and D. J. Hough of New York and has been used in the building of the Pennsylvania R. R. tunnels under New York city. The invention is a large, steel skip made in two sections, fastened together by a hinge at the top of each end and held by a latch at each end near the bottom. These skips are mounted on car trucks in the tunnel and are loaded with earth or rock. They are the body of the cars in the tunnel. When run to the shaft they are either raised to a platform above the street level by means of a cage, when the car trucks and all are raised, or else the skip is raised through an open shaft, there being either guard timbers or rails to prevent it hitting against the sides of the shaft. On the street level the skip is placed on a wagon, it becoming a wagon body. To handle the skips a steel I beam hanger is used with two short chains on each end of the beam, to be hooked to the skip. Such a hanger is used on the hoister at the shaft and also on the derrick at the dump. At the dump the skip is dumped on scows by a derrick, thus saving a dumping platform. A light rope must be used to trip the skip in dumping. With such a skip or wagon body material by means of derricks or cableways can be stored in high stock piles. These skips are raised from the wagon, dumped aboard the scow and placed back upon the wagon in 30 seconds. From the time that a team arrives at the dock to the time that it leaves is only 1¾ minutes, while in the ordinary method a much longer time is consumed. The skip will not dump until it is tripped even with the catches open, as the weight of the load and the location of the supporting chains prevent it. The latches are unhooked before the skip leaves the wagon. The capacity of the skip was 3 cu. yds.

Any derrick skip or dump bucket can be loaded onto a wagon in the same manner and hauled to the dump, there to be dumped by means of a derrick or cableway.

In building the Illinois tunnels in Chicago the Newman dump wagon, invented by Wm. J. Newman, was used to carry the spoil to the dump, where the material was stored in large stock pile, to be used later in land reclamation. The body of the wagon was a square box made of steel and was picked up from the running gear by a derrick and raised over the stock pile, where the bottom of the box dropped down, being held by a number of chains, thus spilling the load. It is stated that this wagon has done very successful work, and has saved money over other methods.

In addition to these wagons there are some others that can be classed under the head of special dumps, as the Cator dump wagon, which dumps on the side, the Turnturtle wagon, which flops over dumping the load, the Bergen Point wagon, which needs a special dumping machine at the dump, and the Tippin four-bucket steel dumping wagon. Each of these wagons will be described later in this series of articles.

(To be continued.)

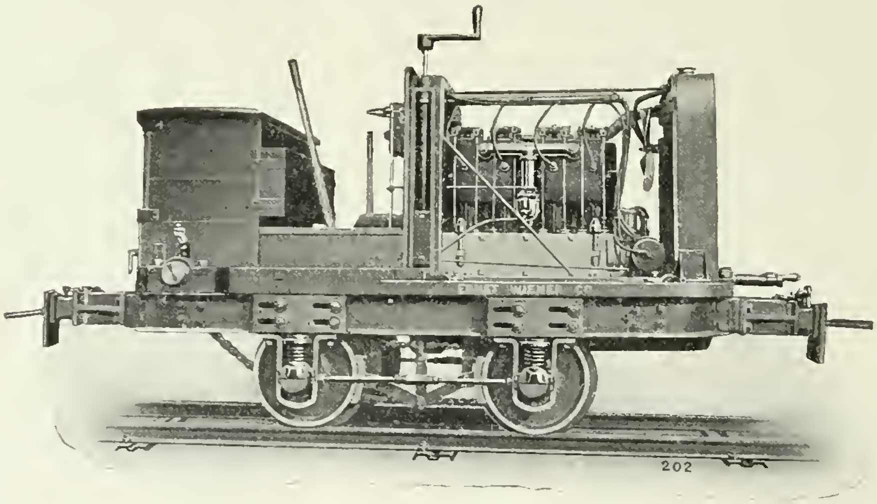
The Government of the Philippine Islands has organized a "Bureau of Public Works" and in this bureau a Division of Irrigation. An annual appropriation of 750,000 pesos is provided for the surveys, plans and construction of irrigation works, and surveys are now in progress. The Governor of the islands has applied for the services of a consulting engineer from the U. S. Reclamation Service, and an effort will be made to detail a competent engineer from that Service at the proper time, at the expense of the Philippine Islands.

The average daily number of laborers actually employed in the Isthmian Canal work in December was 13,694.

A Contractor's Gasoline Locomotive.

A new departure in a contractor's locomotive, or dinkey, has recently been made by the Ernst Wiener Co., of 59 Church street, New York. Instead of using steam, a 4-cylinder gasoline engine is used.

The accompanying illustration shows the locomotive and it is seen that it is simple in construction. The trucks are made up of the Wiener standard one-piece 6-in. channel frame and the standard roller bearing and draft gear. The height is not quite 5 ft., while the length is about 9 ft. The engine shown is for a 24-in. gauge track, and weight 5,000 lbs. The motor is a Brownell, 35-hp. water-cooled type, manufactured at Rochester, N. Y. The power is applied to the rear wheels by chains and transmitted by a sprocket chain to the front wheels, all the wheels being 14 in. in diameter. The locomotive is said to have a speed of from 3 to 12 miles an hour and can climb a 5 per cent grade. The gasoline tank is under the driver's seat and has a capacity of 20 gallons, but its hourly consumption is stated to be one gallon, giving a hauling power of 25 tons.



Contractors' Dinkey Operated by Gasoline Power.

Within easy reach of the driver is the sparking plug, the reverse lever and the lever to control the speed, and a quick-acting brake. To pull out the sparking plug means to stop the engine at once. The driver has ready control of the machine, and the work is no harder than running an automobile. A sand box with an ample supply of sand is also furnished on the locomotive. The vibration is taken up by springs on the trucks and the exhaust gives off but little smoke.

The uses of such a machine are many. For hauling trains of dump cars in connection with steam shovel work is will do the same work, with the advantage that in spotting cars on an ascending grade, the smoke will not interfere with the signals of the man spotting the cars. It can also be used to haul muck from a tunnel, as it will not make smoke to interfere with the work of the men. As the machine is less than 5 ft. high, it can also be used in small tunnels that would not admit of a larger machine being used. It should have an extensive use in sewer tunnels. Owing to its light weight, only 2½ tons, it can be hauled over rough roads into out of the way sections of the country, where it would be difficult for contractors to carry a heavy steam locomotive.

This machine will no doubt be quite useful for hauling concrete and other supplies, as lumber and structural steel, around large structures. Also on sewer jobs, where horses are now used. With industrial railways to serve materials this locomotive will no doubt be found useful.

Use for it will also be found on wagon road construction and in quarries for hauling stone from the quarry to the crusher. One road contractor near Rochester, N. Y., during the past summer, has used one of these gasoline locomotives for this purpose and found it very economical. He stated that with wagons this hauling cost him 29 cts. per cu. yd. per mile, while with this engine he did it for 11 cts. per cu. yd. per mile, thus saving 18 cts., a considerable item.

The Wiener Co. build this locomotive for 24 in., 36 in., and 48 in. gauge and of several different horsepower.

According to the report of the Chairman of the Isthmian Canal Commission the grand total of excavation for December was 3,315,867 cu. yds., of which 1,897,720 cu. yds. were removed by steam shovels and 1,418,147 cu. yds. by dredges.

The third barrage—the Esnah barrage—for controlling the water level in the River Nile was officially declared in service on Feb. 9. The new barrage is situated a distance by river of 162 kilometers north of the Assouan barrage, and stretches across the Nile at a height of 9.2 meters above low water mark. It is 900 meters long, pierced by 120 doors with locks.

Roads and Streets Section

Note: This Section is devoted to methods and costs of road and street construction. It will cover road building in all its details, the construction of pavements, sidewalks and gutters, the testing and use of paving materials and the machinery and tools used in road building and paving.

The Maintenance of Roads and Pavements by European Countries.*

It would be no exaggeration to say that the highway system of France is probably the finest in the world. Its foundation is that of the Roman roads, most of which are still in use as they were laid out and built when Gaul was a Roman province. This system is described in a paper presented by M. Renardier, Engineer-in Chief des Ponts et Chaussees at Orleans, and is made up of five classes, namely: national roads, departmental roads, roads of great travel, roads of common interest and ordinary cross roads, aggregating in length 355,000 miles. The national roads, having a total length of some 18,600 miles, belong to the State and are maintained and improved at national expense. They are designed especially for long distance communication, and are usually of generous width. In some cases these roads are 100 ft. wide between the side ditches, but their usual width is from 25 to 45 ft., while in mountainous regions this is reduced to 15½ and 14 ft., and in some cases to 12 ft. These national roads are the ones generally followed by motor cars. The departmental roads have a length of some 9,000 miles, and roads in this classification are constantly being reduced in mileage. Their width varies from about 37 ft. to 22 ft., while in hilly districts they are about 15 ft. in width. Roads of great travel and of common interest are the property of the communes through which they pass, and the expense of their maintenance is supposed to be borne by these communes, although the departments allow subsidies which materially lighten the burdens upon the communes. The length of these two classes, namely, roads of great travel and of common interest, is now about 152,000 miles. The widths of the roads of great travel vary from 28 ft. to 18.5 ft., while the roads of common interest are from 25 ft. to 9 ft. in width, the smallest width being used in mountainous districts. The fifth class, or ordinary cross roads, are strictly communal, and the cost of their maintenance is paid by the communes, although the State and the departments assist in their construction. These roads are designed especially to serve the interests of agriculture, and they aggregate some 176,000 miles in length.

While the widths of roads as given above vary greatly, the extremes are due to exceptional conditions, but the general width of well traveled roads is about 18½ ft., which is sufficient for two carriages to pass without reducing speed. Less frequented roads are usually given a width of 15.5 ft.

In their alignment the French roads, especially the older national roads, are very straight. The Roman roads which some of them follow appear to be laid out as the shortest possible distance between their termini, while the former practice of laying out roads was to run them "from steeple to steeple." The result is that they not only lack the picturesque beauty of the winding roads of other European countries, but the grades of many of them are unnecessarily steep. Through level districts the grades of the national and departmental roads seldom exceed 2½ per cent, while in rolling and hilly districts they sometimes reach 10 per cent, and on some of the older national roads 15 and even 17 per cent. The cross country roads generally have grades of less than 5 or 6 per cent, while in hilly districts these rise to 8 and 10 per cent.

The minute attention given to drainage and other details of construction and the extreme care with which the roads are maintained are impressive to one accustomed to what must be admitted to be the slovenliness of American practice in these particulars. The side ditches are generally 5 ft. wide at the top, about 20 in. in depth and 20 in. wide at the bottom, and are usually protected by parapets of 20 in. to 2 ft. in height, constructed of earth, sod or masonry.

Tree planting is made a prominent feature of the French highways and it is said that 42 per cent or nearly half of the national roads are so planted, although this practice does not prevail to such an extent on roads of other classes, as their width is not sufficient to permit it.

The French highway system has been an evolution. The work of construction and maintenance is entirely under the control of the Engineers of Bridges and Roads, a thoroughly trained corps of technical men constituting what is probably the greatest engineering organization in the world. All of the roads in commune, department or city are under their jurisdiction. There is no conflicting authority, no diversity of policy or method in contiguous departments or communes. The results have been so striking that the nationalization of highway work has lately been advocated in Great Britain. This policy is in marked contrast to that prevailing in this country, and especially in the city of New York, where in five boroughs there are five distinct highway bureaus entirely independent of each other, each one of which has its own organization, its own methods of administration and its own standards of work. The French system of nationalization might not be adapted to the conditions existing in this country, but that system has resulted in France in the best built and perhaps the most thoroughly maintained highways in the world, while in this city there is palpable waste of energy, material and money, and the results are by common consent unsatisfactory. This is not intended as a condemnation of what we do at home and an exaltation of what is done abroad. We have heard quite enough of that. Street maintenance in Paris, as will be shown later, is expensive, although it is very thorough, while some excellent work is being done in this city; but with a better organization, more co-operation, and more intelligent investigation, vast improvements could be effected.

It is the splendid system of highways which has been briefly described which has contributed largely to the extensive use of motor cars in France, and it is the serious effect of this new method of locomotion upon these roads which was so apparent as to prompt the calling of the First International Road Congress.

Some differences of opinion appear to have lately developed among the French as to the wisdom of the old policy of constant repairs, or the "stitch in time" method. As a substitute for this it has been proposed that the roads be resurfaced when required, and that they then be left alone until general resurfacing is again needed. This plan will be readily recognized as the one which prevails too generally in this country, and, so far as I could learn, it is put forward chiefly by members of automobile clubs who fancy that it would be desirable to get rid of the road workman with his cart and tools and any other of the inconveniences of repair work, so that, for a time at least, there would be nothing to interfere with the unobstructed use of the highways and the high speed of automobiles.

Few, if any, of the French engineers appear disposed to favor this change from the method which has prevailed many years. It has been estimated that the interval which would elapse between such periodic resurfacing has been reduced fully one-half by the automobile.

In England and Wales the country roads are divided into main roads and district roads, but the reason for the classification with respect to any particular road is not always apparent. Prior to 1888 one-half the cost of main roads was borne by the State, but since that time there have been no fixed contributions by the general government, and the burden now falls upon the various counties and districts, and the demands made upon them are in many cases out of proportion to their resources. The methods of administration in England are in marked contrast to those in France. In the latter country there is a high degree of centralization, while in England and Wales there are nearly 1,900 separate boards and councils having jurisdiction over road maintenance. It is said that within 15 miles of Charing Cross, London, there are 90 local road authorities acting independently of each other, and that a main road in 20 miles may pass through territory controlled by ten different highway authorities. Concerted action under such circumstances is manifestly impossible, and while during the last 80 years London and its traffic have increased a hundred fold, it is said that within that period no new main road has been built leading out of the city. There is no uniform organization for the carrying out of improvements. The labor is poorly paid, and in some of the rural districts employment on the highways is considered the last resort before the workhouse. Two years ago there were nearly 150,000 miles of roads in England and Wales, and the total annual expenditure for highway purposes, including installments on debt and interest, was nearly $78,000,000, but how much of this was expended on maintenance and how much on construction, is not clear. The organization and methods followed in the rest of Great Britain are so similar to those of England and Wales as to require no separate comment.

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*From a report on the First International Road Congress submitted to the Board of Estimate and Apportionment of New York City by its Chief Engineer, Nelson P. Lewis.

In Belgium there are three grades of highways known as state roads, provincial roads and conceded roads, all of which constitute a system of high roads called "La Grande Voirie," which are under the control of the Minister of Public Works, while the remaining roads are under the jurisdiction of the districts which they serve. The state roads constitute nearly 80 per cent of the main roads of the kingdom, and the expense of construction and maintenance of them is borne by the State. The system of administration is highly centralized as in France, and the work is entrusted to the "Corps des Ponts et Chaussees," a bureau of which is located in each of the nine provinces.

Holland has a Department of Roads which exercises jurisdiction and control over the main highways. These are divided into three classes, imperial roads, made and maintained by the State; provincial roads, maintained by provincial taxation, although the State bears about one-third of the cost of new construction; and municipal roads, which are built and kept up by local authorities.

In Germany the imperial government exercises little or no control over the highways and does not contribute to their expense. The roads are under the jurisdiction of the different states or kingdoms, although in Prussia the control is generally devolved upon provincial corporations, but the State contributes nearly $5,000,000 annually for the maintenance of the main roads. For the five years from 1900 to 1905 the average amount expended for construction and maintenance of highways in Prussia was about $8,500,000.

The road policy differs in the different states or kingdoms; for instance, in Saxony the government tries to have each locality pay for its own roads, although in exceptional cases the State will pay a large part and in some cases all of the cost of a new road for through traffic if the locality will furnish the land required. The burden of maintenance falls upon the district. In Baden the State pays four-sixths, the commune one-sixth, and the district the remaining sixth of the cost of building a main road, while the expense of the subsequent up-keep is met one-half by the State, one-fourth by the commune, and one-fourth by the district. The communal roads are built and kept in repair by the commune, and disputes as to the duty of a commune in this respect are settled by the courts.

Austria divides its highways into state, provincial, district and municipal, or parish, roads. The administration is vested in and the expense imposed upon the State or the political division indicated by the above classification. There are in the road system of Austria, not including Hungary, some 71,500 miles of roads, of which 9,900 miles are state roads, 2,100 provincial, 37,000 district, and 22,500 municipal, or parish. The annual cost to the imperial government of keeping up the State roads in lower Austria is said to average about $130 per mile.

Switzerland has an excellent highway system and a very efficient and economical administration, although entirely decentralized. The federal government assumes no duties and bears no part of the burden except that a contribution is made for certain roads which are considered international in character. The government can remonstrate with the authorities of a canton if they neglect their roads and can withhold contributions which might be made to that canton for international roads. The work generally is in charge of competent officials and well trained engineers. The limited authority of the central government is believed to impair the efficiency of the highway work.

In Italy the highways are classified in the same manner as in most other continental countries. The national roads are under the direction of a Department of Bridges and Roads and of the Corps of Royal Engineers attached to the Ministry of Public Works. Admission to this Engineer Corps is through competitive examination. The portions of national or provincial roads within the limits of cities or villages are maintained by the locality, but the central government or province pays to the local authority sums representing the cost of maintaining an equal length of road within the limits of the town. In 1904 the total expense of maintenance alone on Italian roads is said to have been nearly $8,500,000.

Spain divides its roads into first, second and third class, which are, respectively, built and maintained by the State, province or municipality. The first class roads are generally 25 ft. in width, second class roads 22 ft., and third class roads about 18½ ft. All plans of projected roads, after approval by the local authorities, are forwarded to the Minister of the Interior, who determines the class to which they shall be assigned. The Spanish road system consisted in 1905 of about 23,800 miles, and the total expenditure for construction and maintenance during that year was about $7,400,000.

Further data upon this subject is available, but it seems unnecessary to include it in this report. The system commonly in use is characterized by centralization of authority and responsibility, and, generally speaking, the greater the degree of centralization the more satisfactory the results, although Switzerland appears to be a conspicuous exception to this rule.

In Australia and Canada the system so familiar in this country prevails, that is, everything is left to the local authorities, the central government exercising no authority or control. In the United States the Department of Agriculture has established an office of Public Roads, but its functions are chiefly educational and it might be called an intelligence office for the dissemination of information concerning highways. This office has a technical staff whose duty it is to build experimental roads and to direct road operation in communities where there is no proper organization for this purpose and where good roads are considered a valuable object lesson.

While the highways of the macadam type and the effect of the modern motor car upon them were the questions most discussed at the Congress, the general subject of city pavements was also considered and was the subject of a number of reports, and the observations which the writer was enabled to make are of at least equal interest to the city of New York. That the automobile has little, if any, effect upon the permanent city pavement was the general opinion of those who contributed to the papers and discussions. As stated by M. Mauhieu: "On paved roadways the action of swift cars seems to have no effect on the wear of materials, and it is evidenced only by the production of a little dust." One contributor, however, maintained that pavements of every description were seriously damaged by motor cars.

A brief description of the pavements of the city of Paris, the materials used, the character of their maintenance, and the cost of the service may be of interest.

On Jan. 1, 1908, the area of the different kinds of pavements in the city was as follows:

	Sq. Yds.
Stone pavements	6,726,100
Wood pavements	2,461,900
Macadam pavements	1,399,500
Asphalt pavements	495,200
Total	11,085,700

The large area of stone pavements and the small amount of asphalt is surprising. The principal streets and boulevards are now paved with wood, which seems to be the popular pavement of the day in Paris. While the first asphalt to be laid upon a street in Paris was put down in 1855, the area of this kind of pavement had in 20 years from that date reached but 310,314 sq. yds., and it was only 495,200 sq. yds. at the beginning of the present year. The increase in the area of asphalt pavement has been but 60 per cent in the past 33 years. During the last 12 years the increase was but 12 per cent, and during the preceding 12-year period 20 per cent. In striking contrast has been the development of wood pavement. Early attempts to use this material resulted in failure, but in 1881 with a new process of treatment success was attained and so popular did this type of pavement become that at the beginning of the year 1908 the area of wood pavements in Paris had reached nearly 2,500,000 sq. yds. During the last 12 years this area has doubled and in the preceding 12 years it had increased 260 per cent. The asphalt pavements are of the type known in America as rock asphalt, and though the kind of asphalt pavement in general use in this country was tried in Paris in 1900 with very satisfactory results, it has not come into general use. The cost of these pavements in Paris is from $2.87 to $3.12 per sq. yd., including a concrete foundation about 6 in. in thickness. The contracts include no guarantee for current maintenance, the annual expense of which is very little, while the total estimated annual cost, including cleaning and a renewal of the asphalt surface, in about 12 years, appears to be approximately 33 cts. per sq. yd.

The wood pavements are made for the most part of native pine from the Landes, a department of southwestern France, though some Baltic or other northern fir is used. The French engineers maintain that very hard native or foreign woods crush the foundation and give unsatisfactory results, and this conclusion appears to have been reached after a long investigation and considerable discussion as to the merits and availability of exotic woods of various kinds. A brief resume of the investigations made as to the availability of the harder woods and the considerations which led to their abandonment is given in a paper by M. Tur, Engineer in Chief of Bridges and Roads, and Assistant to the Inspector General in charge of the Public Highways and Lighting Service of the city of Paris, from which I quote the following:

"The first wood pavements successfully laid in Paris made use of the northern fir or the pitch pine. Since 1884 the pine of the Landes has come into general use and today the use of this wood has become almost exclusive.

"In the pine of the Landes two kinds of wood are found, those from which the resin has been extracted from the trunk of the standing tree and those which have not undergone this process, which has the effect of rendering the lower part of the trunk through which the resin runs out, denser and harder than the upper part; it is this lower part which furnishes the wood used in constructing the best pavements.

"Experiments have been made elsewhere with woods of a widely divergent character. All the different woods of our country have successively been experimented with as well as a great variety of foreign woods grown in warmer climates. We cannot give here a detailed account of these investigations.

"The resinous woods of the Landes or of Northern Europe have frequently been objected to on account of the rapidity of their wear. An effort has been made to remedy this by the use of as hard a wood as was obtainable. The jarrah and the karri of Australia, the teak of Java, the liem of Annam, the iron wood of Borneo, the oak of the French forests—all have in their time enjoyed a certain favor.

"All of these woods had the disadvantage of being very dear, and to reduce the cost per square metre it was necessary to decrease the height of the paving blocks, which, however, was only reasonable since the wear would be very slow. But at the same time it was necessary to devise new methods of laying; the cement mortar could not, as a general thing, take hold of surfaces so absolutely smooth and impermeable: in certain cases these surfaces were coated with hot resin and each block glued to its neighbor, reducing to a minimum the width of the joints.

"Good pavements have never been obtained in this way. Instead of wearing away evenly the blocks rounded off, and under the action of vehicles the pavement soon became rough and noisy. The joints became easily shattered notwithstanding the care with which they might have been constructed; the blocks became movable on their beds, and, under the effect of water and traffic, they acted upon the concrete foundation like metal blocks; the concrete was crushed and large holes appeared in the surface of the pavement, while the rounded tops of the blocks increased the roughness.

"The fact had been lost sight of that as long as roads shall be subjected to the heavy wear and tear of horses' hoofs and carriage wheels, [illegible] it is necessary to give them only solidity and rigidity [illegible] which transmit the vibrations to the less compressible matter. When one lays a road of concrete there is placed a cushion [illegible] of such that road is exposed to the same damage that it would suffer did the vehicles circulate directly upon its surface. To substitute hard woods for soft woods is to take away from wood pavement the essential quality to which they owe their success, namely, the compressibility which smothers sound and deadens the pounding, and thus imparts to the road its longevity.

"It seems necessary to emphasize these points for it has not been without debate that they have been accepted in Paris."

The paving blocks are made and creosoted at a plant owned by the city of Paris, which is said to be the largest of its kind in the world. The joints between the blocks are usually filled with cement grout. The cost of wood pavements is slightly less than those of asphalt, being from $2.70 to $3 per sq. yd., with a 6-in. concrete foundation. The cost of current maintenance is about 5 cts. per sq. yd. annually, while the total estimated annual cost of wood pavements, including cleaning at 12½ cts. and a renewal of the surface at the expiration of nine years, is given at 39 cts. per sq. yd.

Contracts call for no guarantee except to make good any defective workmanship during the first year, but this does not apply to defects in the blocks themselves. The life of a wood pavement in Paris varies from six to ten years, with an average of nine years. Where there is practically no traffic it will last for 15 years, when it will rot and renewal becomes necessary. When the upper surface of the blocks becomes worn and uneven, they are taken up, the worn surface is trimmed off on the street by special gasoline or electrically driven machines, and the blocks are relaid with the trimmed surface down.

Fully 60 per cent of the roadway pavements of Paris are of stone, a large proportion of them being sandstone. Paving blocks are purchased from the contractors or are quarried and made by the city. A large quarry, located in the forest of Marcelaux, is extensively worked. The land upon which it is located belongs to the State, the city being the tenant and having developed the quarry. A stone known as "Yvette" sandstone is taken out in large masses, which are subsequently divided until their greatest dimension does not exceed one metre. The next subdivision is into sizes closely approximating that of the paving stones. These rough stones are then dressed by the stonecutters, who follow a method called "trough setting," the rough blocks being placed in a trough fixed at a height most convenient to the particular workman. In the trough is a bed of sand forming a cushion which is at once elastic and firm, and the workman, with flat chisel and mallet, dresses the blocks to the size and shape required. The paving stones are then transported to the railway station nearest the street where they are to be used. During the last ten years there have been made at this quarry some 6,353,000 paving blocks, of which over 5,000,000 were first class and the remainder second class. The average cost of maintaining the stone pavements is given at 12 cts. per sq. yd. per annum, but this also undoubtedly includes not only actual repairs and maintenance, but an allowance for renewal, although there is no data at hand as to the frequency of such renewals. It does not, however, appear to include cleaning.

The area of macadam in Paris is decreasing, but is still considerable, amounting to nearly 1,400,000 sq. yds., of which about 430,000 sq. yds. are "tarred macadam," a small proportion of which was laid by the mixing method, but most of it is the result of surface treatment. In many quite important streets the central portion of the roadway is paved with macadam, while the sides are of stone block. The cost of maintaining macadam is said to be 38 cts. per sq. yd. annually, but this apparently includes not only cleaning and sprinkling, but the necessary periodic renewals of the surface.

The total expense of maintaining the public highways within the city in 1907 was about $2,425,000, while the cost of cleaning and sprinkling, not including macadam, was about $1,670,000.

The conspicuous feature of highway administration in the French capital is the constant investigation and experiment which is being carried on by trained experts. Analytical investigation of the composition of pavements, instituted by M. Buffet, Engineer of Roads and Bridges, in 1868, has developed into the present municipal laboratory, which has constantly extended the field of its tests and studies until today it is undoubtedly the finest in existence. Apparatus for testing resistance of paving materials to wear by friction was installed in 1868, and in 1873 there was added a machine for testing the resistance to abrasion of stone used in macadam roads. A special drilling machine is in use for testing the thickness and the degree of compression of asphalt pavements. This machine makes a round hole only 1⅜ in. in diameter, which is simply and effectively refilled without mutilation of the pavement. Reference has already been made to the wood treating plant maintained by the city. Constant experiments are in progress to determine the life of this material and the forces which contribute to its destruction. In order that these problems may be most effectively studied, the laboratory makes use of an artificial "rotter," by means of which the action of these forces and elements can be intensified and their effects studied. In Paris, as elsewhere, the difficulty of maintaining pavements on streets containing surface railway tracks has been apparent, and there has been in use since 1905 a device for testing the flexure of rails under the traffic of the cars which they are designed to accommodate and that of vehicles which follow them. Appliances for sprinkling and cleaning the pavements have received much attention. This work is considered a part of street maintenance, although in the case of pavements other than macadam this expense is kept separately, as already indicated.

In cleaning and sprinkling smooth pavements, mechanical appliances are used wherever possible. A horse-drawn rubber sweeping machine consists of a rotary broom sweeper, behind which are segments of rubber, the blades being parallel with the cylindrical broom and overlapping slightly, the effective length being equal to that of the broom. This machine is used after liberal sprinkling of the pavement or after rains. An automobile sweeper, with an eight to ten horsepower motor, making 1,200 revolutions and equipped with electric lights, is now being tried out in one of the sections, while automobiles have been substituted for horses in hauling some of the rubber sweepers above described. A steam sprinkler operated by engines of 30 hp. is now in use, as is also an automobile sprinkling-sweeper operated by a motor of from 15 to 17 hp. The amount of sprinkling which is done appears excessive, and the pavements, while nearly always free from dust, are almost never dry. Sand is liberally used to prevent slipping, and the resulting surface is not pleasant. This excessive use of water may explain the short life of the wood pavement, which, as already stated, is from six to ten years.

The amounts expended upon the maintenance of the pavements of Paris may appear large, but it must be remembered that the figures include entire renewals of the surface when necessary, and there is no information available to determine the annual cost of ordinary repairs which might be compared with the expense of such work in this city. This emphasizes the danger of drawing conclusions from figures given in the reports of different cities or even those made by the different boroughs of this city. Data can be secured from published and apparently authoritative statements issued by different American cities which will appear to justify almost any statement or theory which may be advanced.

It is probable that the actual expense of maintaining the pavements of Paris is somewhat less than the amount expended by the city of New York if the cost of renewals were included in both cases, but that the work is more thoroughly done in Paris and other European cities will scarcely be disputed.

The area of pavements in this city, including all boroughs, as reported at the beginning of the present year, compared with those of Paris, is as follows:

	New York.	Paris.
Stone, sq. yds.	8,380,800	6,726,100
Wood, sq. yds.	287,800	2,464,900
Asphalt, sq. yds.	13,901,500	495,200
Macadam, sq. yds. ...	9,684,500	1,399,500
Total sq. yds.	32,254,600	11,085,700

The vastly greater area of pavements to be cared for in this city is surprising. If, instead of paying for repaving from the proceeds of the sale of bonds running for a term of years far exceeding the life of the pavement, as is our present practice, the entire cost of maintenance, including renewals, were included in the annual budget, the increase in the present tax burden would be considerable. The aggregate appropriations for repairs to and maintenance of pavements for all boroughs for the year 1908 was $2,966,376.50. The amount of corporate stock authorized for repaving was $3,000,000, which is less than usual, and the expense of street cleaning for the current year, exclusive of final disposition, appears to have been about $4,411,000, a total of about $10,380,000 for maintenance, cleaning and renewals. For a pavement area, approximately one-third as great, Paris expended during the year 1907 the sum of $4,095,000. On a basis of equivalent areas the expenditures of New York for the care of its streets are, therefore, some 13 per cent less than those of Paris. If the allowance for repaving had been $3,800,000, as it was in 1907, the cost of the service in New York would have been about 6 per cent less than that of Paris in proportion to area. Considering the lower cost of labor and the excellent organization the sums expended by Paris for this service are very large, but the French people evidently believe that it is worth what it costs.

In Berlin and the German cities generally the pavements are very thoroughly laid and admirably maintained. Their first cost, even with cheaper labor and very efficient organization, is about the same as in this country and in some cases higher. In Leipzig, for instance, the cost of asphalt paving is about $2.50 a sq. yd. for German rock asphalt and $3 where the French asphalts are used, both these prices including the concrete foundation.

Edinburgh is conspicuous for its admirable pavements, especially those of granite block, which is kept in nearly perfect condition both with respect to surface and cleaning. The topography of Edinburgh requires the use of many retaining walls and steps, and the thoroughly good quality of the masonry and the care with which it is maintained impress the most casual observer.

The London streets carry an enormous traffic, and the excellence of the pavements, whether of stone, wood or asphalt, is conspicuous. Openings in the pavements are rarely seen, as when such openings are made they are repaired promptly and skillfully. It is probable that the number of pavement openings in European cities is far less than in New York, as the use of electric light, telephone and other public utilities whose structures occupy the streets is much less general than in American cities. Wooden block appears to be the popular pavement in London, and the manner in which it sustains the enormous traffic of such streets as The Strand is certainly remarkable. The wooden pavement at the lower end of this thoroughfare was found to be in excellent condition, though it had been in use for more than six years. Mr. J. W. Bradley, the City Engineer of Westminster, which comprises that part of London where the traffic is heaviest, informed me that these blocks were 7 in. deep and were laid upon the best possible concrete foundation. Wooden blocks 4 in. or less in depth, as laid on Broadway in this city, would not be used in England under any circumstances. In the West Riding of Yorkshire the standard blocks are 6 ins. deep, while Mr. Robert Phillips, Consulting Surveyor to the Gloucester County Council, in a paper presented to the Congress, states that wood blocks as well as granite blocks are generally 9 ins. in depth on a concrete foundation of 6 ins. Such extreme depth appears to be unnecessary, but I am convinced that in this city a serious mistake has been made by using wood blocks of too little depth. The wood used for paving in England is for the most part Baltic fir or other soft wood, little of the Australian or other hard woods being employed. In London many of the heavy loads are hauled through the streets at night by the use of traction engines or auto trucks. The use of traction engines on the rural highways of Great Britain is increasing very rapidly. Mr. W. J. Taylor, County Surveyor of Hampshire, says that there are now about 8,500 such engines in use on the highways of England and Wales, or about one to every three and a quarter miles of main road. These engines, while slow moving, are heavy and haul wagons with correspondingly heavy loads. This kind of traffic has necessitated the provision of strong surfaces and foundations, and it has been predicted that it will be necessary to build macadam roads which are likely to be subjected to exceptionally heavy traffic with a substantial concrete foundation. This opinion was unqualifiedly expressed Mr. P. W. Henry of this city, one of the American delegates to the Congress, in a paper which he presented.

According to the reports of the Minister of Transportation of the Federal Government of Brazil, there were 10,938 miles of railway in operation in that country on Jan. 1, 1908. At that date, 2,057 miles of railway was under construction and surveys had been approved for 1,150 miles additional.

Unclassified and General Articles

Note: This section is devoted to methods and cost articles on construction work not properly coming under any of the preceding classifications.

LETTERS TO THE EDITORS.

Fuel Required for Steam Curing Concrete Blocks.

Sirs: I have received the Jan. 27th issue of Engineering-Contracting and note that you have published the paper I read at the convention at Cleveland. I note one mistake on Page 61, second column near the bottom. It reads, "as nearly as we have been able to ascertain 1,000 to 2,000 lbs. of coal will cure three ovens of blocks." it should read 1,000 to 1,200 lbs. of coal for three ovens of blocks. Please correct this as 800 lbs. of coal for curing that number of blocks would be quite an item to the manufacturer, and I do not want to go on record as not being able to give a closer estimate on fuel than 1,000 to 2,000 lbs.

Thanking you very much for the courtesy shown me, I remain

Very truly yours,

F. S. Pitts

St. Joseph, Mo., Feb. 2, 1909.

Will Concrete Lumber Make Forest Preservation a Farce.

Sirs: It was with a surprised interest that I recently read an article in your issue of Feb. 3, 1909, entitled "How 'Concrete Lumber' has made Forest Preservation a Farce."

Granting, for the moment, that all you claim for "concrete lumber" is true—that it is destined to displace timber for general industrial purposes, I am surprised that you utterly ignore all aspects of the question of forest preservation other than that which pertains to the direct use of timber for purposes of construction.

You certainly are not unmindful of the fact that it is only through the preservation of the forests about the head waters of our streams that anything like uniformity of flow may be maintained—a uniformity that is absolutely essential to the successful cultivation of the great [illegible] lands of our country, and to the navigation and water power of the future.

The fact needs merely to be pointed to be recognized that the denudation of the forests about the headwaters of the rivers causes great and sudden rushes of water that wash away the soil from above and deluge the farms below, followed by long periods of low water or none at all. I need only to point you to treeless countries for an exemplification of the unreliability of the rivers for the great purposes of agriculture, navigation and water power. No storage of water by artificial [illegible] will be [illegible] useful for all the great purposes mentioned as the storage of the natural [illegible] through the agency of [illegible] forest.

But dismissing [illegible] consideration of the collateral advantages of forest [illegible] and coming to the article mentioned, [illegible] regarded [illegible] fact.

Concrete lumber is good, but can you make it without timber forms?

It may be sentimental folly for the Pennsylvania R. R. Co. to plant trees for future use as ties, but I can not learn of any railroad system in this country that would prefer a concrete tie to a wooden one, and I am of the opinion that concrete ties will be adopted only when the price of wooden ties becomes prohibitive [illegible] time arrives.

You speak of "the folly of setting apart forest preserves and removing them from private ownership and use." Vast sections of our country have been, and are being, devastated and destroyed by the reckless cutting, on the part of the professional lumberman, by the general ignorance and wastefulness of [illegible] and by fires. And the whole intent and purpose of forest conservation is to check this wholesale destruction and to substitute therefor a judicious and well [illegible] use that will supply reasonable wants and, at the same time, keep up the supply.

If, as your article implies, the timber of the future is to become a mere "[illegible] in the ground" then is conservation [illegible] folly, as you maintain. But it [illegible] agrees with me that timber, in view of its utility, both direct and indirect, is [illegible] worth [illegible] ing, and [illegible] [illegible] [illegible] [illegible] word with the rest of [illegible] the great conservation movement a "farce" [illegible] a [illegible].

Respectfully yours,

[illegible]

Chicago, Ill., Feb. 6, 1909.

[Answering our correspondent, [illegible] that forests are needed to regulate stream flow, we are obliged to say that forests serve but little useful purpose in that respect, and such purposes as they do serve will be much more economically and better served by the construction of reservoirs from which power can be developed.

As to forms for concrete, there can be little doubt that steel will be used almost exclusively for forms in the future, because it can be re-used an indefinite number of times and still possess a large scrap value.

As for railroad ties, it is significant that the Italian government, after years of experimenting, has just ordered 100,000 [illegible] inforced concrete ties for use on its railways. One-tenth the money spent in experimenting with reinforced concrete ties that has been spent in buying lands and planting trees for tie timber would have solved the "tie question" for the Pennsylvania railroad. Not six years ago the writer asked Mr. Brown, then chief engineer of the Pennsylvania, why he was building all arch bridges of stone masonry instead of concrete. Mr. Brown's reply was characteristic of the "conservatism" of the Pennsylvania: "When you can show me concrete bridges as old as our oldest masonry bridges, I will be ready to believe that concrete is as durable as stone."

Evidently Mr. Brown was a believer in the Lord's superiority to man as a maker of stone, and could not rid himself of the fallacy of such an attitude. The fact was, however, that the Erie railroad had faced its old masonry culverts with concrete as far back as the 60's.

Our argument is that the forests may even be destroyed by fire, yet most of the land can be more profitably used for other purposes than for raising lumber.

"The great conservation movement" is great only in its narrow-mindedness. It finds its analogy in the old movement to preserve the American bison, or in the still older movement to preserve the stage coach, or in the movement, older still, to stop the use of stage coaches because they were displacing boats. We have quoted once before and we quote again a bit of doggerel written by a poet boatman on the Thames at the time that wheeled vehicles began to be used in Great Britain:

"Carroaches, coaches, jades and Flanders mares
Doe rob us of our shares, our wares, our fares.
Against the ground we stand and knock our heels,
Whilst all our profits run away on wheels."

Education of Inspectors at the Contractors' Expense.

Sirs: In your issue of Feb. 10th, appears an article on "Education of Inspectors at the Contractors' Expense." Evidently the author is a contractor who has been very much "up against it," in the line of incompetent inspectors and worse specifications.

The writer agrees with the author that an incompetent engineer is worse than useless on construction, but he does not agree with the tirade, made by a certain class of contractors, against all inspection. The best set of specifications ever written is worthless unless enforced by adequate field inspection.

The average contractor without attempting to "skin" the job, has his hands full to get any fair margin of profit, even when he devotes all of his energies to the economical prosecution of the work, the handling of labor and the keeping of material in supply. This is, and should be the first interest of the contractor, and it is the only interest of the superintendent or foreman, who is 90 per cent of the time the contractor's sole representative on the ground.

The writer speaks from some experience as a contractor's superintendent.

Should the inspector "keep his mouth shut and trust to the experience of the contractor to do the work in a proper manner?" Certainly not.

It is rank negligence to omit field inspection of any construction which on completion is buried out of sight. This applies especially to concrete work.

In spite of the author's statement, there is a difference beside "vanity" between the engineer in charge and the inspector. It is necessary that the engineer in charge be a man of some experience and that he be of fair and judicial temperament. It is not at all essential that the inspector under the engineer be experienced. Such an inspector is on the ground to carry out a certain definite and limited function, as for example, to see that so many sacks of cement are used per batch, to see that so many reinforcing bars are placed in each panel, and, perhaps, to see that no painting is done over wet or frosty iron.

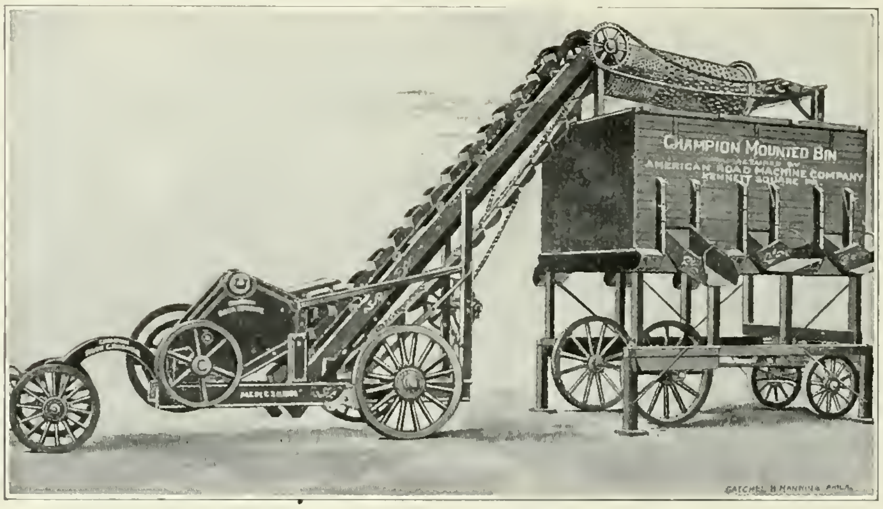
The writer appreciates the fact that there are incompetent engineers supervising inspection of work and that there are bad specifications. This criticism of the article is not made in defence of such, or to encourage any spirit of antagonism between the inspector and the contractor.

There are still some contractors who have not yet learned to make their bid out according to the requirements of the specifications and who must malign all inspectors because they are not permitted to do the work according to their "experience." It is due to the contractor of this type that many railroad and other corporations are performing their construction work with their own plant and organization.

L. K. Sherman,
1500 American Trust Bldg.
Chicago, Ill., Feb. 11, 1909.

A Rock Crusher with Elevator, Revolving Screen and Mounted Bin.

The rock crushing outfit shown by the accompanying cut has been extensively used and merits consideration. The crusher is the Champion crusher, which is distinguished for its large capacity and good wearing qualities. The long jaw plates which afford a large area of crushing surface account in considerable measure for the large capacity of this machine. The crusher is built almost entirely of high grade steel. The main shaft through which the power is imparted by means of the two fly-wheels, is elliptical in shape. One revolution of the fly-wheels, therefore, produces two movements of the swinging jaw. The crusher is made in five sizes, ranging from a small 75-ton per day machine to a large size which will produce from 25 to 40 tons per hour. All of the different sizes of Champion Crushers, except the largest size, are mounted on wheels as shown by the accompanying illustration, when it is desired to use them that way. This crusher is built by The Good Roads Machinery Co., Kennett Square, Pa.



Rock Crusher with Elevator, Revolving Screen and Mounted Bin.

The accompanying table, taken from the Reclamation Record for February, shows the area actually irrigated during the season of 1908 by the various projects of the U. S. Reclamation Service:

State.	Project.	Acres.
Arizona	Salt River	115,000
Arizona-Colorado	Yuma	3,800
California-Oregon	Klamath	9,378
Colorado	Uncompahgre	15,600
Idaho	Minidoka	24,464
Idaho	Payette-Boise	55,000
Kansas	Garden City	5,558
Montana	Huntley	4,400
Nebraska-Wyoming	North Platte	23,220
Nevada	Truckee-Carson	27,450
New Mexico	Carlsbad	8,000
New Mexico	Hondo	1,500
New Mexico-Texas	Rio Grande (Leasberg)	17,000
North Dakota	Buford-Trenton	1,200
North Dakota	Williston	2,000
Oregon	Umatilla	2,500
South Dakota	Belle Fourche	5,000
Washington	Okanogan	1,353
Washington	Sunnyside	42,000
Wyoming	Shoshone	2,600
Total		367,023

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Two Predictions About Panama: That of Engineering-Contracting; That of Engineering News.

Three years ago Engineering-Contracting printed an editorial article in which the economic folly of building the Panama Canal by government forces, instead of by contract, was discussed. A short time later Engineering News took an opposite stand in its editorial columns, and maintained that the work at Panama could be done more economically by day labor than by contract.

From time to time we have published analyses of the unit costs of excavation at Panama, showing a startling lack of economy, and in our issue of Dec. 2, 1908 we gave an analysis that made clear the fact that the canal would cost $280,000,000, including the $50,000,000 paid to the French and to the Panama government. Our editorial of Dec. 2 was copied by the daily press, and commented upon favorably, or otherwise, according to the political affiliation of the paper. In January a Congressional investigation resulted in an admission by the chairman of the Isthmian Canal Commission that the canal would cost at least $250,000,000, and he would not deny that it might not cost $300,000,000. Finally, the commission of seven engineers, who have just returned from Panama, report that the canal will cost $360,000,000, including the $50,000,000 paid to the French and to Panama, and that the canal will be finished in six years more.

In its Feb. 18 issue, Engineering News affirms its belief in the excellence of the work that is being done at Panama, and announces further articles that will demonstrate the soundness of its position. We await the articles with undisguised interest, for it will require a gymnastic logic to twist a unit cost of earth excavation that is greater than the normal cost for rock into a shape that will bear the semblance of economic performance. A grocer selling eggs at 72 cts. a dozen would have much the same task in "demonstrating" their low cost.

In supporting the contention of the government engineers at Panama that they are doing the work satisfactorily, Engineering News may believe that it is merely taking the part of the engineering profession as against contractors. In reality, however, any such position is one reached only by false logic. In the specific case of the Panama canal there would be just as many engineers employed if the work were done by contract as is now the case, excepting that many of the engineers would be in the employ of contractors and at higher salaries than they now receive from the government.

In general, low costs increase the consumption of any product and thus increase the number of men engaged in its production. Roads, for example, now cost about $5,000 a mile to build by contract in the state of New York. Were roads built by state forces instead of by contract, the cost would soon rise to [illegible] or [illegible] a mile, and with what result? Obviously fewer miles would be built and fewer engineers would be required in their construction than is now the case. This reason alone ought to argue [illegible] the direct construction of public works by government forces, even when the interests of civil engineers form the sole consideration.

We cannot believe that Engineering News takes upon itself the defense of [illegible] extravagance in building the Panama canal because it believes that it will gain favor with engineers by so doing. On the contrary we are satisfied that Engineering News simply finds in the Panama work a corollary to a general doctrine that it has long maintained, namely, that of "public ownership of public utilities" and a general socialistic attitude with regard to all forms of human effort. The News sees in the army of men working for the government at Panama the beginning of the realization of its dreams of socialism on a large scale, and it will do its best to convince itself and others that there is real economy manifested in the results at Panama.

Engineering-Contracting is as much concerned with the success of engineers as of contractors, but it believes that the success of both is endangered by every such manifestation of socialism as is presented today on the Isthmus of Panama. It believes in individualism, and therefore in competition, which leads inevitably to a belief in the fundamental economy of doing all public work by contract. It is not unmindful of the short-comings of the contract system, under existing conditions, but it is not deceived by these short-comings into a general denunciation of the contracting system. The mole hill of these short-comings stands only in microscopic prominence beside the mountain of incompetence of the day labor system of doing public work.

It is but a step from the building of the Panama canal by day labor to the building and operating of portland cement factories by government employes, and just another step to the manufacturing of excavating machines and concrete mixers in government shops. In fact the U. S. Reclamation Service has built and operated a cement plant, and the same plan was seriously considered at Panama. In fact, the Canadian government has built its own dredges as well as operated them.

Manufacturers today are contractors, but the policy of the Engineering News applied on the Panama canal is [illegible] it does not lead onward to the manufacture of machines and supplies by government forces, and thus the ultimate elimination of independent manufacturers of all kinds.

But we shall be told that contractors in

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this case at Panama are peculiar. The job is too large for any one contractor, and too complex to admit of more than one. Bosh! The spanning of the continent with a railway is both a large and a complex industrial problem; so is the building of the $100,000,000 Erie Barge Canal; and so are scores of other great projects that have been built by contract.

But, then, there is the tremendously important problem of sanitation at Panama, "which it would be criminal to leave to careless contractors." If sanitation cannot be trusted to contractors, let that part of the work remain in the hands of the government.

The long hauls for excavated material from the Culebra cut will be raised as an objection to doing the work by contract, and a score of other sophistical reasons will be conjured forth, for, where it is desired to establish a precedent, the most insiduous method of argument consists in finding "unusual conditions." Fortunately for such sophistry, and unfortunately for sound reason, no large construction job is free from "unusual conditions," and, having established a great socialistic precedent at Panama by that line of argument, it will be easy to launch every other government project down the same greased ways.

The following table, from a recent consular report, shows the percentage of land occupied by forests in European countries:

Countries	Pct.
England	5.3
Scotland	4.6
Wales	3.9
Ireland	1.5
Denmark	7.2
Netherlands	7.9
France	17.0
Belgium	17.3
Germany	25.9
Hungary	27.5
Austria	32.6

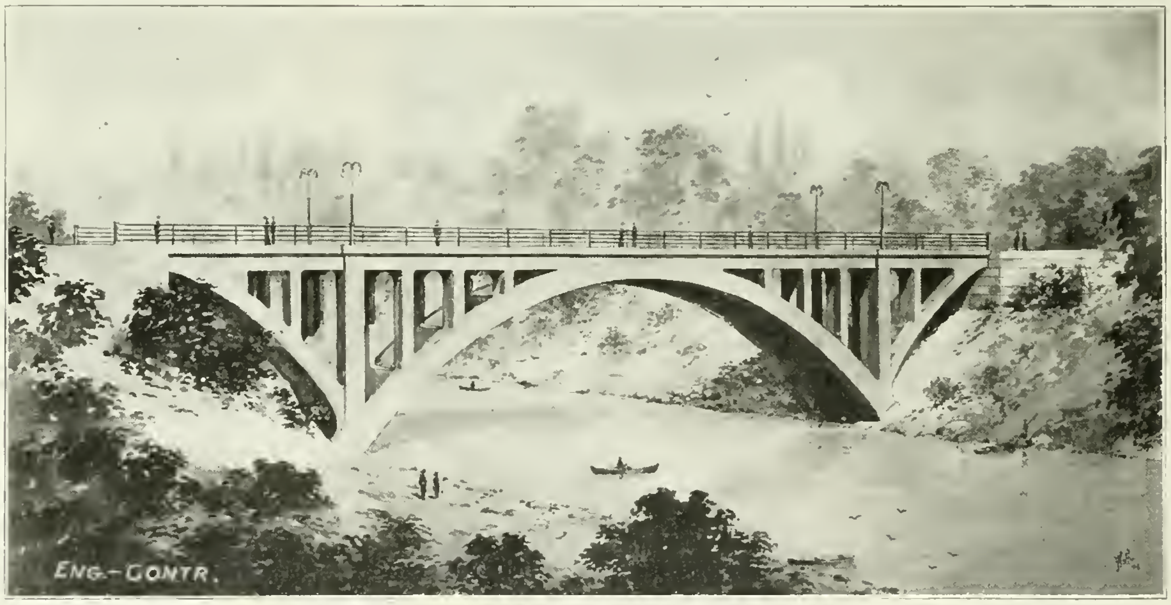
Concrete and Reinforced Concrete Section

Note:—This section is devoted to methods and cost of constructing concrete and reinforced concrete structures. It will cover the selection, testing and proportioning of concrete materials; laboratory tests of concrete; concrete mixing, transportation and placing; fabrication and placing of reinforcement, and form construction and erection. It will also contain articles on new and interesting developments in the design of reinforced concrete.

An Economical Long Span Reinforced Concrete Highway Bridge.*

BY WILBUR J. WATSON,† M. AM. SOC. C. E.

There has recently been completed for Huron County, a reinforced concrete bridge over the Vermillion River, at Wakeman, Ohio, which furnishes an excellent illustration of the economy of this type of structure for similar locations and it is the purpose of this paper to give a short description of the design and construction of this bridge.



Reinforced Concrete Bridge over the Vermillion River at Wakeman, O.

On April 2, 1908, the writer went to Wakeman at the request of the County Commissioners and made an examination of the old bridge, the west abutment of which had failed. This old structure consisted of a wrought iron, half-through, pin-connected truss bridge built by the Morse Bridge Co., in 1878. The length of span was 173 ft. 6 in. and the depth was 26 ft. 2 ins. The height of floor above the river bed was originally about 40 ft. About five years ago some changes had been made in this bridge and the height of roadway had been increased about 6 ft. until it was only a few feet below the top chord of the trusses. The abutments had been raised the required amount by the addition of concrete walls built on top of the old masonry which was of Berea sandstone.

The failure of the west abutment consisted of the giving away of the south wing thereof, while the north wing was badly cracked and showed considerable movement and gave indications of failing at any time. As before stated this abutment was built of Berea standstone but only the facing was of first-class masonry, and while being of sufficient thickness to have stood provided it were well built and properly drained at the base of the wall, it actually consisted of three distinct walls one within the other, the two back walls being of very poor construction, consisting of large stones, but with practically no bonding to the front wall or to each other so that the front wall was carrying all of the load and actually failed by crushing of the stone.

The writer estimated that to rebuild this abutment properly would cost approximately $6,000 but estimated that the old abutment might be removed and an additional steel span on steel posts be put in for about $4,000.

An examination of the iron superstructure was also made and it was found that this was in poor condition. If everything had been in good condition this iron bridge would have carried safely a concentrated load of about 10 tons or a uniformly distributed load of about 60 lbs. per sq. ft.

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*Paper read before the Ohio Engineering Society.

†Cleveland, Ohio.

of roadway. However, many of the vertical posts were badly bent, due very largely to the peculiar construction of the bridge and to the fact that when the roadway had been raised, the ends of the bridge had been concreted in and no provision had been made for expansion and contraction. It was not deemed possible properly to straighten these posts without taking them out of the structure and as this entailed the complete dismantling of the trusses and rebuilding them, it was figured that this could not be done for less than $2,000 and the bridge would not then be sufficiently strong to carry the loads which it should be able to carry. In view of the fact then that this bridge could not be rebuilt for less than $8,000 and would then not be as strong as it should be, it was decided to build a new bridge and the writer was commissioned to prepare plans and superintend the construction.

The writer had already at the request of Mr. Laylin, County Engineer, made an approximate estimate of the cost of a reinforced concrete arch at this point, placing the figure at $18,170. While the writer decided from the first that a reinforced concrete bridge was the proper construction for this particular structure, it was decided to ask for alternative propositions on both concrete and steel designs.

The bridge as designed and as constructed consists of a single 3-hinged reinforced concrete arch of 115 ft. span center to center of lower hinges, and 32 ft. 6 ins. rise center to center of lower and upper hinges, with cantilevers at each end of 37 ft. 3 ins. length from the center of the lower hinges to the ends of the cantilevers giving a total length of 219 ft. 6 ins. between abutments. The width of the roadway is 18 ft. between curbs and the total width of bridge is 21 ft., the arches being designed for the addition of sidewalks at any time in the future, provision for which has been actually made by imbedding bolts in the concrete on the south side of the bridge.

The arch consists of two parallel ribs. The reinforced concrete floor which constitutes the wearing surface of the roadway is carried by longitudinal and cross-beams which in turn are supported by spandrel posts carrying their loads to the arch rings.

There are two great advantages to this type of construction over the solid arch with earth fill between the solid spandrel walls. One is the provision of a concrete wearing surface for the roadway, which we know, now, furnishes almost an ideal wearing surface for light traffic, and the other is the absence of waterproofing which becomes a very serious problem in the case of a solid filled arch. In addition to these two advantages, the lightness of the construction which reduces very much indeed the thrusts on the abutments is also a great advantage.

The 3-hinged type of structure was selected for two reasons. In the first place, all stresses were absolutely determinate, there being no uncertainty whatever in regard to the stress in any member of the bridge, and in the second place it was actually cheaper for a structure of this particular type than a hingeless arch. In this particular structure the thrust at the crown for a 3-hinged arch was 501,000 lbs., while the thrust at the crown for a fixed arch was 520,000 lbs. The principal economy, however, of the 3-hinged over the hingeless arch for an arch of this type and dimensions was due to the decreased bending moments in the arch rings caused by the cantilevers.

As a matter of fact, the sum of the total bending moments at each panel point in the 3-hinged arch amounted to only about 25 per cent of the sum of the total bending moments in the hingeless arch. The cost of the hinges necessary for the 3-hinged arch was very considerably less than the cost of the additional steel reinforcing in the arch ring required to take care of the additional bending moments in the hingeless arch. This is a matter that the writer went into with considerable detail as he confesses that he was rather surprised himself at the result and could hardly believe it until he had carefully checked over the figures. The result certainly constituted a very decided argument in favor of the 3-hinged arch. The cast steel hinges are entirely encased in concrete, this having been done after the centers were struck, a ¼ in. plate of sheet lead having been placed at the center of each hinge to allow the necessary motion of the arch rib under live load and temperature stresses. In this way all possibility of corrosion of the steel hinges has been avoided.

The cantilever ends decrease the dead load thrust on the center hinges about one-quarter, decrease considerably the angle which the resultant thrust on the lower hinge makes with the vertical, thus decreasing the size of abutment required and eliminate entirely the necessity for providing sliding expansion joints.

The elimination of the sliding expansion joint is a very desirable feature in a bridge of this character, as such joints are difficult to construct and are very apt to give trouble.

There is no connection whatever between the ends of the cantilevers and the abutments, an open vertical joint being provided at these points. The vertical motion of these joints is a negligible quantity in a structure of this kind.

The foundations of the new work, which are new, are rock at the east end of the bridge and a good quality of shale at the west end of the bridge, the footings being carried down about 8 ft. below the water line in each case.

The rock is evidently the top of the Berea sandstone but is very rotten and uncertain at this point and although plainly exposed to view in the river bed and in the sides of the hill, it was necessary to blast out large quantities [illegible] in [illegible] fall [illegible] the [illegible]. We [illegible] encountered a small pocket of quicksand.

At the west end [illegible] till [illegible] rock [illegible] all but doubtless were [illegible] the [illegible] same location [illegible] hard to support the footings. As the load on the footing did not exceed [illegible] per sq. ft., we did not consider it necessary to carry the excavation to rock.

The east abutment consists of the old abutment, the only changes made thereto being the addition of a new bars [illegible]. The old west abutment was razed to the line of the slope, large quantities of stone taken therefrom being deposited against the toe of the fill to prevent against scour. At the west end of the bridge a new abutment was built from stone taken from the old west abutment and then faced with concrete for the sake of appearance.

One of the features of the construction is the use of a very large part of the iron from the old bridge which was carefully cleaned by scraping and burning off the paint and placed in the new bridge as reinforcing material, most of it being put into the arch rings, vertical posts, and the top stringers. A very satisfactory part of the construction was the use of the eye bars of the lower chord of the old bridge together with the end diagonals to take care of the tension caused by the cantilever ends, in the longitudinal beam along the top of the new bridge.

Provision was made at the [illegible] of the center hinges for connecting the eye bars to the hinge by means of a pin. From the hinge the eye bars extended along the top longitudinal beam toward the ends of the cantilever where the bars from the two sides of the bridge were bent around the end and joined together. The connections between the eye bars were made by the use of pins from the old bridge. These pins and the heads of the eye bars furnished the best kind of anchorage for the bars in the concrete. Twin square high carbon bars were used for the roadway floor. The unit stresses in the steel reinforcement were limited to [illegible] lbs., but the maximum stresses in the reinforcing rods in the posts and in the main arch [illegible] did not exceed in any case more than one-half the amount.

A gas pipe railing was adopted because it permitted of easy removal when the future sidewalks, which will be supported upon steel brackets, are placed upon the bridge.

Proposals were received by the Board of County Commissioners of [illegible] County on June 1, 1908, and ten bids were received. The engineer's estimate was $17,480, while the highest bid received was $[illegible] and the lowest bid, that of the Schillinger Bros. of Columbus, was $15,075. One bid received was for $11,784 for a steel bridge, but as this steel bridge did not have the carrying capacity, that is, it was not figured for as heavy live loads as the engineer's design, it cannot be compared with the same as to cost. Two alternative designs were submitted for reinforced concrete arches, the bid of one being $17,671 and that of the other $18,865. Both of these bids were upon solid spandrel-filled arches and did not provide for a pavement, the addition of which would very considerably increase the cost over these figures. The alternative designs submitted by one of the bidders consisted of steel designs only. This party submitted six alternative designs, the highest priced design being comparable in capacity and pavement to the engineer's design and amounting to $17,869.75. The lowest priced design was for a cheap steel bridge with a timber floor and lighter load then the engineer's design for which the bid was $14,781.75, or almost as much as the lowest bid received on the engineer's design.

The successful contractors made a difference of 1 ct. per pound between furnishing the new reinforcing steel in place and putting in place the old iron reinforcing. As this difference is considerably in excess of the scrap value of the iron at present prices, it shows that it was economical to dispose of the old iron in this way. The engineer's estimate shows a difference of 1½ cts. between new steel and old iron and some of the unsuccessful bidders made as much difference as this. In fact, one bidder made as much as 2½ cts. difference between the two items, while one bidder made no difference at all. However, there was not one bidder out of the ten that did not make at least 1 ct. difference and most of them 2 cts. difference.

The bridge was proportioned to carry a uniformly distributed live load of 100 lbs. per sq. ft., or a live load of 18 tons concentrated on four wheels 5 ft. gage and 10 ft. center to center of axles with an impact stress added to the concentrated live load equal to that given by the formula

$$I = \frac{S\ 150}{L + 300}$$

where I = impact stress; S = calculated maximum live load static stress, and L = length of loaded distance in feet which produce the maximum stress of the member.

The unit stress allowed on steel bars was 20,000 lbs. per sq. in. in the roadway slabs where high carbon bars were used and the maximum stress was caused by the concentrated live load, and 16,000 lbs. in all other places. The corresponding stresses in compression were 12,000 and 10,000. The maximum allowed compression in concrete was 750 lbs. per sq. in. under cross bending stresses when computed by the straight line method (which corresponds to about 640 lbs. actual unit stress) and 500 lbs. per sq. in. under direct compression. No allowance was made for concrete in tension. The maximum allowable shearing stress on concrete was 50 lbs. per sq. in.

All concrete used in the arch rings, floor and arch details was composed of 1 part cement, 2 parts sand and 4 parts stone (¼ to 1½ in.), while the concrete for the skewbacks was composed of 1 part cement, 3 parts sand and 6 parts stone.

No facing mortar was used, but great care was taken to ensure the flushing of the concrete against the forms.

In the construction of the centers an allowance of 1 in. was made for settlement of forms, etc.

Some changes were made in the work during construction consisting of additional grading, additional masonry in the west abutment, etc., bringing the final estimate up to the sum of $16,870.45, which it will be seen is about $600 less than the engineer's estimate.

The contract was awarded to the Schillinger Bros. of Columbus, Ohio, and Chicago, Ill., and work was commenced on July 1. The excavation for the east piers was commenced on July 15. The method of construction is briefly as follows:

Posts were set on the rock bed of the river, a dowel pin being placed in the bottom of each post. This false work was carried only as high as the center of the lower hinges of the new arch. The west end of the old iron bridge was lowered upon cribbing built upon this false work. Two panels of the bridge at a time were taken down, the cribbing being carried back and placed under the bridge as it was needed. The east end of the bridge during this time remained upon its abutment. This method of lowering the old bridge served to cause any possible settlement in the false work before it was called upon to carry the concrete of the arch. Considerable difficulty was experienced in taking the old structure down, since the clearance between the pins and the eye-bars were so small that it was a very difficult matter to drive out the pins. The old bridge certainly exhibited a very high degree of workmanship which doubtless made it perform its work satisfactorily for so long a time in spite of the fact that it was such a very light structure.

While this bridge was being taken down the excavations were made for the skewbacks and the concrete placed therein. The forms for the ribs were also made during this time in the contractor's yard at the west end of the bridge. The plant consisted of a concrete mixer placed at the west end of the bridge and an engine and derrick, the latter being placed as close to the location of the west abutment as could be done. The material from the excavation for the west skewback and also the material from the old west abutment and from the slopes was handled in buckets by this derrick and deposited south of the approach to the west end of the bridge. This derrick was provided with a 70 ft. boom. A small stiff-legged derrick was used on the old bridge to remove the top chord and to lower down the bridge. After the excavation was completed, the boom of the big derrick was shortened to 50 ft., run straight up, a steel cable run across the river, and all forms and lumber were carried out by this cable. It was also used to remove the forms when the work was completed. A runway was built on top of the cross beams of the false work and the concrete was carried out on this runway and dumped into place.

Two men were kept constantly spading on each side: The concreting of the main ribs was begun on Oct. 7 and finished on Oct. 12. Then the columns were concreted and the longitudinal beams. The cantilever forms were then finished and the bend panels of the cantilevers were concreted so that no settling would take place when the rest of the cantilevers were run and thus make possible a crack where the cantilevers joined the main columns. The concreting of the floor was finished Nov. 1 and the centers under the arch ribs were struck on Nov. 16. The settlement of the arch ribs on removal of the forms was 3/64 in.

The bridge was built under the direction of the authorities of Huron County, Mr. John Laylin, County Engineer, and Mr. Herrick, Assistant County Engineer, with the writer as consulting engineer. The writer was represented on the work by Mr. E. E. Cowin. B. U. Childs, A. G. Felton and E. K. Jennings were the members of the Board of County Commissioners.

The contractors were Messrs. Schillinger Bros. & Co., as before stated, the work being done under the immediate direction of Mr. John McMichael as superintendent, with Mr. Edward Madden as foreman.

Lehigh Portland cement was used throughout the work, the crushed stone being furnished by the Bellevue Stone Co. and the sand by the Lake Erie Sand & Construction Co. of Huron. The high carbon steel rods were furnished by the Buffalo Steel Co. The steel railings were furnished by the Republic Structural Steel Co. of Cleveland and the steel castings by the Bucyrus Steel Casting Co. of Bucyrus, O.

The best daily record of excavation on the Isthmian Canal for steam shovels since American occupation was made on Feb. 5, when 56 shovels in the Central Division removed 73,442 cu. yds., an average of 1,311 cu. yds. per shovel. Of this amount 17 shovels in the Empire District excavated 26,004 cu. yds., an average of 1,530 cu. yds. This is the highest daily record, states the Canal Record, that has been made; the highest previous daily record was made on Dec. 18, when 50 steam shovels in the Central Division excavated 70,087 cu. yds., an average of 1,402 cu. yds. per shovel. These shovels are under steam for eight hours per day.

The grand total of excavation on the Isthmian Canal for the 25 working days of January was 2,924,551 cu. yds. All of this amount except 154,919 cu. yds. was taken from the canal prism.

The Bonding of New to Old Concrete.[*]

BY E. P. GOODRICH, M. AM. SOC. C. E.

The necessity, in his general practice of securing as perfect a bond as possible between masses of concrete which are deposited in abutting positions, but with longer or shorter intervals between the times of deposit, together with several demands for expert opinion as to the adequacy of the bond secured under certain given circumstances and with certain materials and methods, led the writer to make investigations into the history of the art, and to perform a series of experiments in the laboratory of the Polytechnic Institute of Brooklyn to determine how closely it is possible to approach a truly monolithic condition at such joints, when care is taken in executing the concreting in their vicinity.

LITERATURE OF THE SUBJECT

The principal editorial in "*Engineering Record*" of Aug. 29, 1908, discusses this subject with particular acumen. The remarks end with the statement:

"To sum up the whole matter in a phrase, the real obstacle militating against the bonding of fresh concrete to old, is dirt. This dirt may be an oily substance or a finely comminuted material forming an inert stratum constituting a most objectionable divided joint, or any similar substance which prevents the new crystals of setting from attaching themselves continuously to those already existing. It is commonly supposed and stated as a general proposition that new concrete cannot be bonded to old. There may be room for legitimate difference of opinion as to the practicability of attaining that end. Any process not feasible of execution under ordinary conditions of work may be so difficult as to be practically impossible, but some engineers of experience believe that bonding new concrete to old will not long be classed in that category. If such a bond be attempted with a truly clean surface experience shows that intelligent manipulation involving some pressure will insure invariably successful results. It has many times been done on a small scale, and it is not too much to expect that under suitable conditions further experience intelligently directed may accomplish the same ends under ordinary circumstances. Efficiency of concrete work will be greatly enhanced in many cases if such an important end can be uniformly attained; and when it can be done on a small scale, ultimate success on the large scale of usual engineering works is not too much to expect."

The use of oil in some form, coated upon the forms so as to prevent the adhesion of any concrete to them, is a direct cause of much trouble when a good bond is desired between the old concrete and any further concrete, stucco, grout, etc. The primary reasons for the use of the oil are:

(*a*) To prolong the life of the forms (the alternate wetting and drying tending to rapid deterioration), although the natural life is not usually long enough to make this item of much importance.

(*b*) To lessen the labor incident to the removal of the forms.

(*c*) To lessen the breakage of the forms due to sticking while being removed.

The handling of oil about any parts of the work is likely to provide sufficient material to add to the natural difficulty of securing good bond at far distant points. Men carry it on their clothes, their shoes, and their hands, and, as it usually floats on water, a thin film is likely to rise to the top surfaces of fresh concrete everywhere and remain on top of the concrete when the excess water evaporates. There is seldom enough alkali in the cement to saponify completely such oil within any appreciable lapse of time, and, even when such saponification does take place, the soaps thus formed are sometimes not readily soluble in water, and there is practically never sufficient water used to dissolve and remove them, even when they are soluble.

For these reasons, the writer has lately made it a practice not to coat his forms, or else to use soap for the purpose; either hard or soft soap is suitable, and the only drawback to its use is its relatively higher cost. Its prime advantage is its solubility in clear cold water. When soap is used, it is necessary merely to flush the surface thoroughly with water to remove the otherwise troublesome film. In securing a bond, the excess water is useful for other reasons, as well.

Laitance is often responsible for imperfect bond. This point is discussed in the following remarks by L. J. Hotchkiss[*] on "Some Details of Concrete Construction":

"Occasions will arise, however, where a longitudinal joint in a wall is necessary, and where this is the case the thorough cleaning of the concrete is often neglected. The laitance is not all removed and dirt, shavings and sawdust are permitted to remain in the forms. This work cannot be left entirely to laborers, but must have efficient supervision and inspection. The surface of the concrete should be scrubbed with wire brushes and water until every stone shows clearly, and the water used in the scrubbing should be flushed off and not left standing in the forms with the laitance in suspension, to be deposited on the concrete again as soon as the scrubbing gang has gone. Both time and expense can be saved if the cleaning is done before the concrete becomes hard. It can be done with shovels and a small amount of washing instead of the protracted scrubbing necessary later. The bond obtained in even the most carefully cleaned joint is of uncertain strength, and if the cleaning is poorly done, there is no bond at all."

Shrinkage cracks almost invariably reveal themselves in reinforced concrete floors along the joints between successive days' work. After a time, retaining and other walls of mass concrete very often reveal even the horizontal joints between successive deposits, and the writer knows of one such wall through which water has found its way to such an extent along such joints as to ruin the appearance of the face of the wall and actually cause anxiety as to its continued stability.

Taylor and Thompson[†] cite an instance "In the New York Subway," where:

"Work was commenced with no provision for bonding horizontal layers, but it was soon found that more or less seepage occurred, and in one case where a large arch was torn down the division line between two days' work was distinctly seen."

In demolishing old concrete work with wedges and sledges, an experienced workman always looks for the joints between successive layers, and the writer has often seen large masses separated by using only a crowbar when the old seam had been discovered. The commonly observed hollow sounds which issue from cement sidewalks and floors under traffic when the floors and walks have been constructed with special cement finish coats are always due to a separation having taken place between them and the base course. This is obviously due to poor bond. After any considerable lapse of time, stucco, mortar, plaster, and grout which have been applied to mass concrete work, are oftener found to have separated than to have retained a perfect bond with the backing.

Gillette and Hill[*] call attention to one primary reason why proper bond is difficult to secure on horizontal and other much worked concrete surfaces, where the mortar has been flushed to the surface.

"Concrete which has set hard has a surface skin or glaze to which fresh concrete will not adhere strongly unless special effort is made to perfect the bond. * * * The secret of securing a good bond between fresh concrete and concrete that has set lies largely in getting rid of the glaze skin and the slime and dust which form on it."

In a paper on "Construction Details of Reinforced Concrete Work,"[‡] De Forest H. Dixon, Assoc. M. Am. Soc. C. E., says:

"The sloping off of concrete in the beams and girders should never be allowed. It is a well known fact that there is almost no bond between old and new concrete."

And again:

"Granolithic finish should be placed monolithic with the slab, or, if placed afterwards, which is desirable in stables, and some other classes of work, its thickness should never be less than 1½ in. Recently, an acid solution has been placed on the market which the author has tried in several instances, using, in some cases, finish as thin as ½ in., put on concrete that had attained an age of several months. This finish has been in place for three months, and thus far shows a perfect bond."

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[*] Slightly condensed from a paper read before the American Society of Civil Engineers and published in the proceedings for January, 1909, p. 15.

[*] The [illegible]

[†] "Concrete, Plain and Reinforced," p. [illegible]

[*] "Concrete Construction, Methods and Cost."

[‡] Proceedings Municipal Engineers of the City of New York, 1907, p. [illegible]

The specifications prepared for large engineering works to be executed in concrete usually contain a short clause with regard to bonding old and new concrete, but they are rarely at all explicit, the exact treatment usually being left to the resident engineer for determination. The following is the standard specification for work of this class, incorporated in all the published requirements for the several parts of the new Catskill Water Supply Development for New York City.

"For the proper bonding of new masonry to old, such provision shall be made of steps, dovetails, or other devices as may be prescribed. Whenever new masonry is joined to old, the surface of the old masonry shall be thoroughly cleaned, using stiff brushes and a stream of water; the laitance shall be scraped off and the surface shall be clean and wet at the moment the fresh concrete or mortar is placed. When ordered, a thick wash of rich mortar shall be brushed over the contact surface of the old concrete."

This specification is typical in the main, being rather better than most of the others in the writer's possession.

In the construction of tunnels, and heavy or extensive work of all similar kinds, joints are inevitable, and the designer must study each case carefully and devise proper quantities and arrangements for the reinforcement which is essential to securing the work against the appearance of shrinkage and temperature cracks along such natural joints. The subject of setting, shrinkage, and change of size, from fluctuations of temperature and humidity, are intimately connected with the subject of bonding old and new concrete, but will not be discussed here, although they have all been investigated, both experimentally and analytically, by the writer in this and closely related work.

Another and a very vital and closely related question, and one which exists in the minds of most constructors, is as to the proper place in reinforced concrete floor-beam constructions at which to leave the joint between successive days' work. In the last analysis, if a perfect bond could be secured between the successively deposited masses, it would not matter in the least how or where one day's work were stopped. Usually, a compromise has been deemed best, and the joint made at about the quarter point in the span of a beam or slab, where neither the bending moment nor the shear is a maximum.

PATENTED PROCESSES.

All the treatises on concrete discuss this important subject of bonding, but tell very little of real value. Ernest L. Ransome, Assoc. Am. Soc. C. E., has secured several patents on the general treatment of concrete surfaces, with mechanical bonding devices and with acids, to secure a better connection; and other methods have been devised which make use of bituminous and other compounds to be applied to the old work and in preparing the new mortar. These are mostly used where it is the intention to apply stucco or plaster to mass concrete. Usually, these compounds are also claimed as resisters of dampness as well as bonding agents. Only one such process, not primarily for damp-resisting purpose, is known to the writer. In it a special preparation of coal-tar is used in the place of water in mixing the mortar for the new floor or sidewalk wearing surface.

The first patent (No. 647904), issued to Mr. Ransome, concerning the subject of bonding, was dated 1898, and covers a "concrete joint strengthened with a metallic coil embedded in both of the joined masses."

Patent No. 694578, also issued to Mr. Ransome, covers:

"The method of forming a bond between two bodies of concrete, which consists in first sprinkling over the surface of the first made body of concrete while yet soft and unset, a layer of prepared honeycomb slag, embedding the same into the surface, allowing the concrete to set and after removing all superfluous slag, covering it and embedding its exposed surfaces with the second body of concrete."

Patent No. 767582, issued to Mr. H. L. Lewman, is:

"In a concrete construction, adjacent sections connected by a bendable tie-piece having looped portions embedded in each section with its free ends meeting at its mid-length, and a connecting strip extending between said looped portions of the tie-pieces and having its free ends bent to intersect the body thereof, or with a rod extending through the opposite loops of each tie-piece at an angle thereto."

The best known of these patents is No. 800942, issued to Mr. E. L. Ransome in 1905. It has to do with:

"The improvement in the art of forming structures of concrete and the like, which consists of forming a layer of plastic material containing cement, and permitting the same to harden, in removing portions of the hardened surface of said layer by the application of an acid thereto, in removing from said surface by washing the excess of acid and resultant salts and disintegrated material, and in forming a second layer of plastic material containing cement, over said surface of the first layer, and permitting the second layer to harden, whereby to form a perfect bond between the two layers."

In a pamphlet describing the use of a special mortar for cement floors, stucco, etc., Albert Moyer, Assoc. Am. Soc. C. E., gives the following method of securing proper adhesion between old and new cement in cement floor work:

"Sweep off the concrete surface thoroughly with a broom, wash the surface with clear water and sweep off with a broom. As soon as the excess water has been taken up by the atmosphere or absorbed in the concrete, paint the surface with a solution of one part commercial muriatic acid, three parts water; paint on three coats one right after the other. Within a few minutes wash off the surface with clear water, sweeping with a stiff broom. This removes all particles of dead cement which may remain on the surface, exposing each grain of sand and other aggregates which compose the concrete in very much the same condition as they were before being mixed. This also wets the concrete quite thoroughly.

"While the concrete is still wet, place an inch coat of mortar * * * ."

The removal of efflorescence from concrete work, by the application of an acid wash, is so similar in method and result to that required in obtaining a perfect bond that the following description* may well be included for the sake of completeness:

Commercial hydrochloric (muriatic) acid, diluted with from 4 to 5 parts of water, was applied, and the surface scrubbed with common floor scrub brushes, water from a small hose being constantly played on the concrete while the cleaning progressed, so as to prevent the penetration of the acid. The cost on straight work was estimated at about 2 cts. per sq. ft. cleaned. An experienced stone renovator should be employed whenever possible. Hydrochloric, acetic, and oxalic acids were experimented with, in conjunction with the scrubbing. All were effective. Hydrochloric acid was the best, requiring less scrubbing. Acetic acid came next in efficiency.

In this case the endeavor was simply to remove the thinnest possible layer from the surface, the acid being prevented from penetrating to any appreciable extent. In the patented process for securing decorative surface results on concrete by etching with acid, covered by letters patent No. 716371 granted to Block and Richards, Dec. 23, 1902, the method is closely analogous to that necessary to secure a good bond, and is described as follows:

"The process of producing a natural finish on artificial stone composed of cement and particles of natural stone by subjecting it when molded and dried to a solution of muriatic acid, then rinsing the same in water, then subjecting the same to a solution of carbonate of soda, and finally rinsing the same in water."

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*Abstracted from Engineering News, October 31st, 1901.

PUBLISHED EXPERIMENTS

Few experiments have thus far been published with regard to methods of bonding masses of concrete, but in "*Engineering News*" of Aug. 13, 1908, is given an abstract of a graduation thesis prepared by Raymond B. Perry, of Case School of Applied Science. He prepared and tested by flexure small concrete-beam specimens, 2¾ in. square and 27¾ in. long, which had been spliced at their centers. A variety of methods of splicing were used, none of which developed the strength of an unspliced specimen. His results and deductions are repeated here for future reference and comparison.

"While experiments of so limited character are not absolute in their results, it may be concluded with some degree of certainty:

"(1) That the bond existing between new mortar or concrete and old, where the old surface is smooth, is very slight.

TABLE I.—PERRY'S TESTS

Condition of Joint Surface Treatment.	Roughened. Wet.	Smooth Grouted	Rough Grouted.	Smooth. Ransomite	Moulded Groove	No Joint
Results of tests, in pounds per square inch	158	119	279	232	175	255
	123	131	211	128	133	230
	87	207	237	220	120	249
	124	82	225	231	128	271
	128	124	227	146	110	257
Av. in lbs. per sq. in.	124	133	236	191	133	252

"(2) That about one-half of the strength of the concrete is developed in a joint bonded (*a*) by roughening the old surface; (*b*) by applying a layer of cement paste; (*c*) by providing the old surface with a bonding groove.

"(3) That a large part of the strength of the concrete, perhaps as much as 90%, is developed where the old surface is roughened and a layer of cement paste is applied.

"(4) That such a solution as 'Ransomite' practically takes the place of the roughening, since a bond made with it is otherwise similar to the one made in these tests by roughening the old surface and applying a layer of cement paste."

"Ransomite" is a powder which is to be dissolved in water in order to obtain the bonding solution.

These tests closely followed some experiments described in "*Annales des Ponts et Chaussées*," Pt. 3, Vol. 27, 1907, the results of which were summarized as follows in "*Engineering News*" of Dec. 12, 1907:

"A (neat) cement joint is an aid in connecting old concrete work to new, and * * * whether this joint is used or not, an excessive tamping of the new work near the joint will add appreciably to the strength of the connection."

TABLE II.—FRENCH TESTS

Spliced after:	7 Days		30 Days	
Treatment of Joint	No grout	Grouted	No grout	Grouted
Results of tests, in pounds per square inch	24	209	171	159
	97	175	154	302
	67	300	142	227
Average, in pounds per square inch	63	223	156	229

It is stated that the above splices made after 30 days, were better tamped than the earlier ones. It is also to be noted that the mechanical arrangements of the test brought a considerable direct compressive stress upon each joint, and in consequence these tests are not strictly comparable with any others.

The specimens were of the same size and kind as those described above, and all are open to the objection of revealing results comparable only with one another, as there is at best only an approximate relation between the maximum stresses developed in bending and those produced under direct stress.

Professor Morsch* gives the following results, showing that the direct stress may be considered to be about one-half that developed in bending when computed according to the usual formula. The stresses are in kilograms per square centimeter.

The writer is not aware of any experiments having been made with regard to the bonding qualities of stucco or cement finish for concrete floors or sidewalks, except a single test with brick as a backing, made by Professor Ira H. Woolson, at Columbia University, for the exploiters of a special water-proofing cement mortar. His report reads in part as follows:

"Description of Specimens.—Two specimens were submitted for test, and each consisted of a common red building brick, with a coating on one side of about one-half inch of the cement. The cement was thoroughly dry and hard.

TABLE III.—MORSCH'S TESTS.

Mixture	1:3		1:4		1:7	
Percentage of water	8	12	8	11	8	11
Bending stress	21.4	22.2	16.1	16.7	[illegible]	12.8
Direct tension	12.0	10.5	9.2	8.8	4.4	[illegible]

"Object of the Test.—The object of the test was to ascertain what degree of heat the cement would sustain without injury either by cracking or by disintegration.

"Method of Test.—In order to develop the full effect of possible differences in coefficients of expansions due to heat in the two materials, the specimens were heated on the cement side only, and the brick kept cool as it would naturally be in a wall, where the face of the wall was heated. To accomplish this object, the specimens were laid, one at a time, horizontally over a side opening in a small gas blast furnace. To insure that the heat be uniformly distributed over the whole face of the cement, a 3-16 in. sheet of compressed asbestos board was used to close the furnace opening, and the cement face was placed near to it, but not touching.

"In this narrow air space between the cement and board the thermo-couple of a Le Chatelier electrical pyrometer was placed, by which the temperature at the face of the cement would be accurately and continuously recorded.

"The heat was raised gradually and temperature read every three minutes. The total time of heating the first specimen was 45 minutes, and the temperature attained was 1000° F. At the time no cracks or other defects were noticeable in the cement and the brick was cool enough to allow its being easily removed from the furnace by the bare hand. However, in a few minutes after removal, a crack developed along the line of juncture, between the cement and brick, which gradually spread until it had separated about half of the cement from the brick.

"The cement adhered to the brick so firmly that the crack in places ran into the body of the brick itself. No other disintegration occurred.

"The second specimen was heated the same way, but the time of heating was reduced to 14 minutes, and the temperature to 600° F.

"This specimen showed no effect whatever due to the heat either hot, or later when it had fully cooled.

"It is quite evident that the cracking of the first specimen was due to unequal expansion of the brick and cement, and rapid cooling. It is possible that the cracking might not have occurred if the specimen had cooled slowly."

(To be concluded.)

At a meeting of the Washington Society of Engineers at Washington, D. C., on Feb. 16, Mr. Van H. Manning, Topographer of the U. S. Geological Survey, gave an illustrated lecture on the overflow lands in the Yazoo Delta, in which he outlined the preliminary investigations which are now being made by the United States Geological Survey in cooperation with the State of Mississippi, looking to the reclamation of 7000 square miles extending south along the Mississippi River from a point ten miles south of Memphis. Following this lecture the Society gave an informal reception to the following engineers who accompanied President-elect Taft to Panama: Frederic P. Stearns, John R. Freeman, Isham Randolph, Capt. Charles P. Allen, Allen Hazen, James D. Schuyler, Arthur P. Davis. The other out of town guests were W. H. Code, Chief Engineer Indian Reclamation; L. C. Hill, Supervising Engineer U. S. Reclamation Service; Marsden Manson, City Engineer San Francisco.

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* "Eisenbetonbau," p. [illegible]

Earth and Rock Section

Note: This Section is devoted to methods and costs of excavating earth and rock and building embankments. It will cover the grading of roads and railroads, diking and canal work, dredging, building reservoirs and earth dams, sewer and water pipe trenching, quarrying, etc.

Comments on the Use of Wagons in Transporting Earth.

(Continued from p. 132, Feb. 17, 1909.)

Wagons have been used in trains in the Rocky Mountains and the far west for a great many years in hauling materials and supplies where there are no railroads. At one time horses were entirely used to draw these wagons, from 6 to 24 horses being hitched in a team and from two to four wagons being coupled together. The driver rides one of the wheel horses and drives the long string of animals, hitched in pairs, with a jerk line. However, this jerk line does not control the two horses hitched to the end of tongue of the first wagon, just in front of the wheelers. These two horses, known as "the point horses," are quick and active animals and are trained for their work. All of the lead horses except these two are hitched to a long chain, running from the tongue, and when the wagons are to be turned the lead horses, being guided by the jerk line, pull in the direction in which the wagon is to go, while one of the "point horses" jumps over the chain and the two pull in the opposite direction. This keeps the wagons from turning too short which would cause them either to upset or break the coupling of the back wagons.

Hauling in this manner has been more economical than with single teams, as the long team of horses are able to pull along the train of wagons on level or easy grades, while, when heavy grades are encountered, the train is broken up, and the wagons are pulled up these grades either single or in pairs, the entire team of horses being needed on the steepest mountain roads for hauling a single wagon. This same method could be used for hauling construction materials and also for hauling earth.

Today in the west traction engines are supplanting the horses for pulling these trains of wagons, and in some cases, as in hauling lumber, the number of wagons in a train has been increased. In the Boer war in South Africa traction engines with strings of wagons were used to haul military supplies. This method was introduced from Europe, where the wagons are called "cars," and have been used in trains for many years. In fact, the first dump cars invented were used in Europe before the days of railroads and were pulled by horses in short trains. With traction engines and a string of wagons economical hauling can be done.

For construction work this method has been but little more than introduced into the United States. There are several types of traction engines on the market for this class of work. One is a three-wheeled engine, another being the four-wheeled type. Some have a locomotive cab, and some have the engines mounted over the boilers, while others are undermounted. The greatest use to which engines and wagons have been put in construction work has been in hauling lumber, and also crushed stone for wagon road building. There is a great use of such trains of wagons in earth work.

The greatest usefulness of this method will no doubt be found in making excavation from large pits and carrying the material over a long haul, into large structures, as reservoir embankments, dikes or levees. Today such work is either done by means of locomotives and cars or by single teams. The steam propelled train of wagons will be found more economical than single wagons, and in many cases the train of wagons will do work cheaper than the locomotive and train of cars.

In building large earthen embankments for reservoirs trains of wagons are especially adapted to this work, and the more so if the embankment is high. Borrow pits for high embankments are generally opened at an elevation about midway between the base and top of the embankment, and the grade of track laid to start the work and likewise to finish it is generally very steep, making it necessary to use short trains of cars. Then for every different elevation of the embankment the track has to be changed for the locomotive and cars. The traction engine and train can take a heavier grade than the locomotive, and it will make its own road over the embankment.

Another expensive item in building large embankments with dinkeys and cars is the continual shifting and lifting of the tracks to make the layers, the tracks also interfering with the spreading of the earth, and, to some extent, the picking out of stones or cobbles. Much of this expensive work is entirely eliminated when a train of wagons is used with an engine. With the ordinary dump wagon with a short tongue so they can be coupled together, work of this kind can be done, but a number of wagon manufacturers are now placing on the market a special wagon for this character of hauling. Such wagons have about 5 cu. yds. capacity, will spread or partially spread their load and have broad tires on the wheels. If the wagons will not spread their loads, or if the layers are too thick, either a device can be attached to the wagon to spread the earth, or a road machine can be coupled to the train on the dump, and thus spread the earth as it is dumped. The heavy traction engines and the heavy wagons with broad tires would also do much towards compacting the layers, thus materially reducing the cost of the rolling. This, too, would mean that many stones and cobbles that are now picked out of the earth, because they interfere with the rolling, would be mashed down into the embankment.

This would save much money in the embankment work and would give a better embankment. The writer believes that the actual hauling would be as cheap, but the cost of the plant would be higher, but this cost, distributed over a large yardage, moved each year and over several years' work would only amount to a few cents per cubic yard. In wet weather such a train of wagons could not go onto the embankment, while a train of cars could, but the feature that governs embankment work as done with cars is the spreading and rolling, and a traction engine with 3 or 4 ft. tread wheels could work whenever possible for the rollers to be used.

Instead of laying down several permanent railroad tracks from the borrow pit to the embankment, as is done for a locomotive and cars, a wide macadam road should be built for the wagons and engines. The cost of the two, and their maintenance, will not vary much.

Such trains of wagons can readily be loaded with a steam shovel, in a manner similar to a train of cars, but the quickest work can be done in an open pit, worked from one side only, as on a side hill.

A derrick car, derrick, cableway or locomotive crane with a grab bucket could also be used for loading the train of wagons. With this method of loading the excavation can be made at a much lower elevation than that upon which the wagons are loaded.

Another method of loading a train of wagons is by means of an elevating grader. The train of wagons would pull up alongside of the grader exactly as a single wagon does, and the train and grader would start off at the same time. As soon as the first wagon is loaded the grader would slow up until the second wagon came under the conveyor, when the speed of the grader would be increased, and the second wagon would be loaded. This operation would be continued until the entire train was loaded. With this method a grader would be worked to nearer its real capacity, as instead of loading from 1 to 2 cu. yds. of loose material and then stopping, 5 cu. yds. of loose material would be loaded without a stop, and with but little lost time from 20 to 30 cu. yds. would be excavated, according to whether 4 or 6 wagons are used in the train. With one train following close behind another in a large pit, but little time could be lost by the grader.

If solid body wagons have to be used to haul material, there are several devices on the market for dumping such wagons. These have not been used for earth, but there is no reason why they should not be, as well as for crushed stone or any material that will dump by gravity.

One of these devices is known as the overhead wagon dump. It consists of a large wooden roller mounted overhead, with a gear wheel on one end. A chain runs from this wheel to a hand power on the elevation of the wagon. Two ropes attached to the roller are hooked onto the front of the wagon and by winding the ropes around the roller the front of the wagon is raised so that its load is dumped out of the end of the wagon. It is not necessary to block the wheels of the wagon, nor is there any danger of breaking the coupling pole. The load can be dumped through a trap from a platform, or over the edge of the platform and even on level ground. The ropes are fastened over the hubs of the front wheels.

Another device is one for use on a platform, two pieces of timber being pivoted near the center, upon which the wagon is driven, when the timbers are tripped by a lever. When the lever is thrown there is no control over the wagon, which rocks with the timbers, thus dumping its load.

The Evans wagon dump operates in a similar manner, except that the tripping device is such that it is always under the control of the operator. The wagon is dumped by means of a lever operated by the dumper's foot, and is righted by a crank. A strong brake keeps the wagon and the dumping device under the control of the operator at all times. The wagon can be lowered part of the way and then lowered farther for the discharge of the balance of the load.

These dumping devices have been used in grain elevators for dumping farmers' wagons delivering wheat, but there is no reason, as previously stated, why they cannot be employed for other materials. These three devices are all manufactured by the H. W. Caldwell & Son Co., of Chicago, Ill.

No matter what kind of a wagon is used, or the material that is hauled, there should always be kept a record of the loads made by each wagon used. The record should show the time consumed in loading for each trip and the time of making the round trip. The length of the haul should also be recorded. With such a record every minute of the day is accounted for, the distance traveled each day is also recorded, and the number of trips made. In this way a unit cost per mile of either a cubic yard or a ton is obtained and the efficiency of the team and driver is shown.

Such a record means cutting out of lost time, the regulating of the teams so only enough are employed to make the run and keep the loading force steadily employed.

There are a number of ways of keeping a wagon record. By means of tally boards, having the wagons numbered; by means of time cards upon which the record is kept, or by means of punch cards. For different materials or different lengths of hauls different colored cards can be used.

There are a large number of dump wagons, dump boxes and contractors' wagons on the market. Not only are these wagons made by many different manufacturers, but one manufacturer often makes many different styles of wagons. Although these articles have to a great extent been confined to the use of wagons for earth excavation, yet in order to call attention to all the wagons known to this journal, that are now on the market, so that engineers and contractors may learn to know them all, we will consider all the uses to which such wagons can be used, and make comment on the various features of the different wagons.

The manufacturers, themselves, issue catalogs, pamphlets and circulars descriptive of their wagons and calling attention to their good features, and any one wishing to learn more of each make of wagon than we are able to give in our limited space, should apply directly to the manufacturer, whose address will be given.

The writer has had an extensive experience with many different makes of dump wagons hauling various materials, and has studied the method of operating most of the wagons on the market, besides having discussed the use of dump wagons with many engineers and contractors, as well as manufacturers and their sales agents. Accordingly he hopes the comments made may be of assistance to others, and that such comments may be considered as the expression of opinion not only of himself but of others who have either used or manufactured wagons.

(To be continued.)

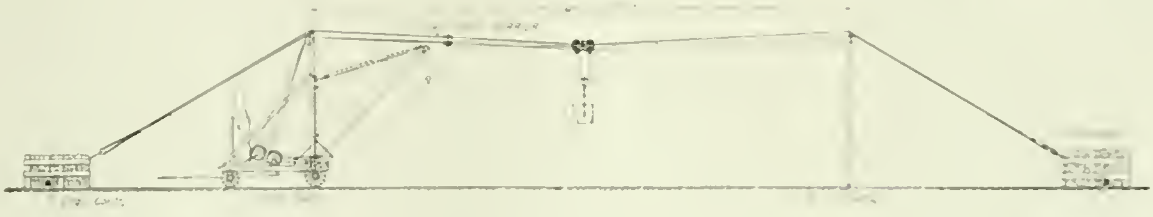
In constructing the new magnetic survey yacht for the Carnegie Institute of Washington vanadium bronze, a new non-magnetic metal, will be used. A gas producer will be used to create motive power.

A Combination Cableway and Derrick.

Today the use of cableways for building sewers is rapidly increasing, as is also the use of portable derricks. With both machines good work can be done both in excavating the trench and in placing materials in the construction of the sewers. On this page we illustrate a combination cableway and derrick designed for spans up to 500 ft., that promises to find a great field of usefulness in not only building sewers but in many other classes of construction.

The general plan is extremely simple. The derrick is built on a car with a hoisting engine and boiler. Over the A frame for the derrick is erected a head tower for the cableway. A tail tower is erected at the other end of the work and the cableway strung and anchored to dead men as shown. In moving the cableway, only the tail tower need be taken down.

It is possible to use both the derrick and cableway at the same time, or work can be carried on with either. This arrangement means a saving in time in carrying on work. This design was gotten up by the New York Cableway & Engineering Co., 2 Rector St., New York.



Combination Cableway and Derrick.

The following table, abstracted from the report of the Secretary of the Interior, shows estimated cost and per cent of completion at Dec. 31, 1908, of the various approved projects of the U. S. Reclamation Service:

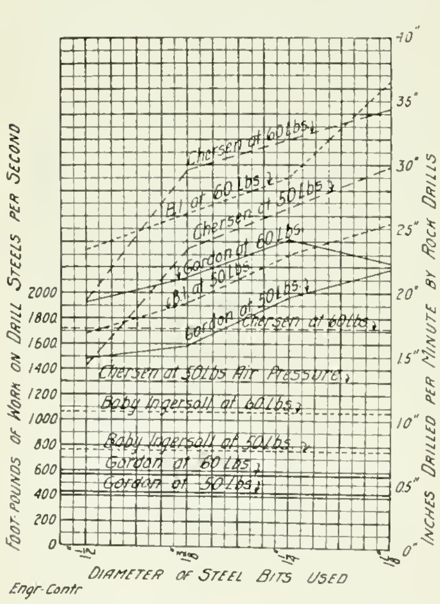
Location—Project	Estimated cost	Per cent of completion
Arizona—Salt River ...	$[illegible],900,000	61.6
Arizona-California—Yuma	5,630,000	[illegible]1.0
California—Orland	1,500,000	11.2
California-Oregon—Klamath	5,930,000	28.5
Colorado—Grand Valley	2,500,000	2.0
Colorado—Uncompahgre	7,500,000	64.0
Idaho—Minidoka (gravity)	1,780,000	100.0
Idaho—Minidoka (pumping)	600,000	35.2
Idaho—Payette-Boise South Side Division	1,765,000	47.2
Kansas—Garden City	377,000	100.0
Montana—Lower Milk River	6,270,000	1.0
Montana—Huntley	810,000	100.0
Montana—Sun River Fort Shaw unit	480,000	100.0
Nebraska-Wyoming—N Platte	4,200,000	93.3
Nevada—Truckee-Carson	4,300,000	90.0
New Mexico—Carlsbad	640,000	100.0
New Mexico—Hondo	370,000	100.0
New Mexico—Rio Grande	8,000,000	.8
New Mex.—Leasburg unit	210,000	100.0
North Dakota—Buford Trenton	316,000	100.0
North Dakota—Nesson	740,000	4.5
North Dakota—Williston	471,000	100.0
North Dakota Montana Lower Yellowstone	2,751,200	82.5
Oregon—Umatilla	1,208,100	82.0
So. Dakota—Bellefourche	3,400,000	58.8
Utah—Strawberry Valley	2,880,000	21.9
Washington—Okanogan	585,000	77.8
Washington—Sunnyside	2,253,000	39.1
Washington—Tieton	1,800,000	74.8
Washington—Wapato	3,600,000	5.6
Wyoming—Shoshone	7,560,000	42.0
Total	$89,431,500	

The Efficiency of the Blow Delivered by a Pneumatic Hammer Drill.

In our issue of July 1, 1908, we published an account of a contest of different makes of pneumatic hammer drills in South Africa, the article being condensed from a paper delivered before the Transvaal Institute of Mechanical Engineers by Prof. J. Orr. In the discussion that took place on this paper Mr. J. H. Hughes gave the following data on the efficiency of the blow struck by some of the drills used in this contest. The Gordon drill, manufactured by the Ingersoll-Rand Co., of New York, won this contest.

"I have tried to find out the most efficient blow to be delivered on to drill steels of different diameters, and the following notes may be of interest.

I have calculated the number of foot-pounds of work expended upon the rock per second, by the Chersen, Baby Ingersoll and Gordon rock drills, using the figures given by Mr. J. A. Vaughan for the number of blows delivered by each rock drill as being approximately correct. In the following table I have worked out the percentage increases or decreases for the three rock drills mentioned, all working on a steel bit of 1¼ in. diameter; but from the curves submitted, any other diameters of steel bits may be dealt with in the same manner.



Engr-Contr

Diagram Showing Efficiency of Blow.

In the curves I have taken the average drilling speed of each drill when operating upon the second hole, but eliminating all holes drilled in the granite block marked D.

From the table it will be seen that with a percentage difference in foot-pounds of work done in the "Chersen" and "Gordon" drills of 67.3 per cent at 60 lbs. pressure, and consequently in the air consumption of the two drills on their forward strokes, the difference in drilling speed is only 21.8 per cent.

TABLE OF FOOT LBS. OF WORK EXPENDED ON ROCK PER SECOND.

Type of Rock Drill	Foot lbs. at 60 lbs. Air Pressure	Percentage for Comparison	Foot lbs. at 50 lbs. Air Pressure	Percentage for Comparison
"Chersen"	1,720	100	1,312	76.4
"Baby Ingersoll"	1,058	61.6	760	44.2
"Gordon"	563	32.7	430	25

Speed of Drilling in Inches Per Minute with 1¼-in. dia. Steel Bit (Averages of Second Holes Drilled in Granite Blocks A, B and C.) (See Engr.-Contr. July 1, 1908, p. 9.)

Type of Rock Drill	Inches Drilled Per Minute at 60 lbs. Pressure	Percentage for Comparison	Inches Drilled per Minute at 50 lbs. Pressure	Percentage for Comparison
"Chersen"	3.22	100	2.65	75.3
"Baby Ingersoll"	2.90	90.0	2.31	71.8
"Gordon"	2.42	75.2	1.93	60

And in a difference of 32.2 per cent in the work expended in the "Chersen" and "Baby Ingersoll" rock drills, there is only a difference of 3.5 per cent in the drilling speeds.

Other comparisons would naturally suggest themselves.

From the above data I conclude that it is preferable to deliver a large number of light blows, such as are given by the Gordon, to a smaller number of heavier blows, as, evidently, the latter blunt the steel bits too quickly. The hammer type of drill, as was proved in the case of the Kimber, has the disadvantage that the steel bits are very apt to stick in the hole when drilling at a depth of 30 to 40 ins., even with automatic rotation of the bit. I therefore, in contradiction to the conclusions arrived at by Professor Orr, *re* the superiority of the hammer type of rock drill to the reciprocating type, think that the best type of rock drill for stoping purposes will be of the reciprocating type, but which will give a larger number of lighter blows than the types at present in use."

A bill is to come before the State Legislature of Iowa providing that civil engineers be appointed by the Board of Supervisors in every county to supervise the building of roads, bridges and drainage ditches. The bill will require the county engineer to pass upon plans and specifications upon which bids for large jobs are submitted and to prepare plans himself for smaller jobs and road work when requested. He would have supervision over all road work and would stand between the township or district road supervisors and the state highway commission. A salary of from $1,000 to $2,000, at the discretion of the Board of Supervisors, will be provided and the board will be permitted to go outside the county to secure competent engineers when necessary.

The total number of Isthmian Canal employes actually at work on Dec. 31, was 21,417.

The Cost of Breaking Up Boulders by Heating.

One method of breaking up large boulders that is not much used is by heating. The work is very simple. The boulders are heated by building a fire around and on top of them, and after the rock has become pretty hot, cold water is thrown on them with the result that the rock breaks up into several pieces that can be easily sledged into one or two-men stones. In clearing a lot of land, some years ago, for a real estate development the writer used this method. The waste wood from the trees had to be burnt, and by piling this around the surface boulders, they were broken by being heated and having water thrown upon them for less money than it would have cost by using explosives, considering the fact that the waste wood had to be burnt.

Another place where this method can be used is in digging cellars in cities and towns. A few large boulders may be found mixed in with the earth excavation and without a derrick they cannot be loaded to be hauled away. It is dangerous to "mudcap" them, and to drill them may mean the buying of both steel and hammers. A contractor in New York has accordingly adopted the heating method under these conditions.

Recently in excavating a celler he encountered four large boulders, one with 1¾ cu. yds. in it, and one with 1⅛ cu. yds. These two were found on the same day. The rock was mica schist. That evening two men worked overtime to break up these boulders. Discarded boards used in the runways were split up to make the fire. In an hour the stones were heated enough to break them so they could be sledged, and 15 minutes more were consumed in sledging them. Thus the first breaking by heat cost 30 cts., with wages at 15 cts. per hour and the sledging cost 7½ cts. This gave a cost of about 10 cts per cu. yd. for the heating and about 3 cts. per cu. yd. for sledging.

On another day a boulder having 2¼ cu. yds. in it, and one with 1½ cu. yds. were dug out and it took two men 2 hours to heat and break these, the extra time being needed on account of the increased size of one of the boulders. This was at a cost of 16 cts. per cu. yd. for breaking up the boulders so that they could be loaded into a wagon by hand. Nothing has been allowed for the wood as it was waste and would have been thrown away.

The Hudson & Manhattan R. R. Co., which operates the McAdoo tubes under the North River, at New York City, has applied to the Public Service Commission for a franchise to extend its tunnel system from the present terminal, at Sixth Ave. and 33rd St., to the Grand Central Station, to connect with the Steinway, or Belmont, tunnel under the East River and with the present subway.

Roads and Streets Section

Note: This Section is devoted to methods and costs of road and street construction. It will cover road building in all its details, the construction of pavements, sidewalks and gutters, the testing and use of paving materials and the machinery and tools used in road building and paving.

Method and Some Costs of Telford-Macadam Construction in Pennsylvania.

During 1908 the State of Pennsylvania constructed 292 miles of macadam and telford roads at an average cost of $10,000 per mile, for a 16 ft road 9 ins deep, this cost including all bridges, culverts, etc. In the Journal of Engineering of the University of Colorado, Mr. I. C. Jordan describes the construction in Pennsylvania of the telford type of roads, and the matter that follows has been taken from his article.

The roads of the telford type have the foundation built of any good local stone and the top course of crushed limestone. The road surface is 16 ft wide with a 2 ft shoulder or berm and a 2 ft. ditch on either side. The extent of one contract averages about 2½ miles, as this is the most economical length, although one section may cover as much as four miles. For a contract of this size, if all stone is within a convenient distance, the following equipment besides smaller tools is necessary:

1 Crusher, capacity 80 tons per day.
1 Traction engine for running crusher.
1 Stone bin, 60 tons capacity.
1 10-ton steam roller.
8 or 9 Dump Wagons, 15 cu. ft. capacity.
1 Rooter.
2 Plows of different weights.
1 Sprinkling wagon.
4 or 5 Wheel Scrapers.

When practical, it is best for the contractor to hire teams, some with farm wagons.

The first step in grading consists in plowing the cuts. Where the surface has been much traveled during the years preceding, it is necessary to use the heavy plow pulled by the traction engine. When excessively hard surface is encountered the rooter is required. The dirt is usually moved by means of dump wagons loaded with shovels, although wheel scrapers are frequently employed where the haul is short. All fills must be made in layers not exceeding a foot in thickness, each layer being thoroughly rolled before the next is added. An economical number for the grading gang is 15 to 20 men and four to six teams, depending on the amount of grading and the length of haul. The subgrade is usually left rough and is smoothed up by the Telford gang.

The advance of the Telford layers, consisting of four to six men, shapes the grade by means of pick and shovel. The crown must be the same as desired in the finished road, because the layer of broken stone is of uniform thickness. The grade thus finished should be thoroughly rolled before the Telford is set. The main body of the Telford gang, consisting of 15 or 20 men, throws the stone in from the side of the road, sets it by hand, knocks off the rough points of the surface and forms the berms along the sides of the road. The best method of doing this where there is much travel on the road is to set one side of the roadbed at a time, always squaring it up each night. The chief difficulty in employing this method is encountered when wet weather sets in with only one side finished, thus allowing the other side to be worn down by the traffic. The Telford should be well rolled before the surface stone is applied.

The crushed stone surface is the most important part of the construction. If the Telford is laid ahead, the placing of the broken stone may proceed in either wet or dry weather. This layer of stone is usually about four inches deep while loose, and is compressed to about three inches when rolled. A large amount of rolling is not required. A covering of limestone screenings, one and one half inches thick, is placed on top of the broken stone. This is alternately rolled and sprinkled until the limestone dust and stray particles of clay work up into a paste which runs ahead of the roller and forms a slush over the entire surface. It is best to let the road stand for half a day or more after this treatment, so that the second application of rolling and sprinkling will be more effective than it would be otherwise.

The layer of screenings does not appreciably increase the depth of the macadam as most of the screenings work into the interstices of the crushed stone. Indeed this action is the chief function of the fine stone, for in this manner it makes the top layer of the coarser stone firm. Just how this action occurs is not clear. Whether it is chemical or only physical is not settled. These facts are patent, however: *First*, the bond is best when the road is damp; *second*, the binding action takes place every week or two throughout the year with precisely the same material. These observations seem to indicate chemical action.

The surface is next swept with a coarse stable brush which seems to bring out the surplus water, leaving the solid particles in close contact with each other. It occasionally happens that the surface hardens so well that the marks of the brush are visible after the road has sustained several days' traffic.

A road which Mr. Jordan superintended during the summer of 1907 is briefly described as a representative example of road construction in Pennsylvania, as follows:

The quarry, which was advantageously located near the middle of the section and 20 ft below the road surface, consisted of a 14 ft stratum of limestone [illegible] 17 ft of shale and clay. The crusher was set at the same elevation as the road, the stone being drawn up on a platform level with the crusher's jaws. The crusher was run by a 20 hp traction engine. A stationary boiler supplied steam for the hoisting engine and for a steam jet which forced the water from the quarry. A bin of 65 tons capacity proved fairly satisfactory, although a larger one would have given less trouble in regulating the hauling to the road. With this equipment and that ordinarily found in this kind of work, the cost ranged about as follows:

Grading, per cu. yd.	$0.75
Telford hauled 1 mile, including royalty of 10 cts. lin. ft. (⅓ cu. yd.)	.30
Laying and rolling, per lin. ft.	.20
Crushed stone, 65 cts. per ton + 7 cts. royalty	.72
Haul for first 2 miles, per ton	.20
Haul for remaining 1⅛ miles, per ton	.50
Average haul, per ton (about)	.31
Stone delivered, per ton	1.03
Or per lin. ft.	.11
Spreading, sprinkling and rolling, per lin. ft.	.11

With these unit costs we have the following:

Grade (average), per mile	$1,500.00
Stone work, berms and ditches, per mile	7,500.00
Culverts, pipes, head walls, gutters, underdrains, road approaches, etc. (variable), per mile	1,000.00
Total	$10,000.00

Obviously, the cost will depend wholly on local conditions. Where the soil is good and all stone is near at hand a considerable reduction from the above figures may be made.

Much of the work done was open to criticism as to method: (1) Frequently the selection of the road to be improved was influenced by favoritism. In a few instances a stone road in fairly good condition was torn up when the money could have been expended to better advantage on roads which had never been artificially surfaced. (2) The inspectors were often men of very inadequate knowledge of road building. In one instance a 9 per cent grade was reduced to 6 per cent at considerable cost when there was an 8 per cent grade nearer to the town to which the pavement was being laid. (3) The benefits of good roads might be extended to a larger number if some of the roads were built less than 16 ft. wide, which width was uniformly used. Indeed a more skillful and a less biased use of the same resources would very often have done a greater service.

A few general observations present themselves to one engaged on the work. Economy may be effected if it is possible to unload the telford material directly on the finished grade. Although this is usually not practicable, yet a saving of at least $400 per mile may be made when it is done. On the other hand, if the stone is piled along the sides when the weather is favorable for hauling, the work of actual construction may proceed even in wet weather when the fields are too soft to allow hauling.

Regular construction should always be given precedence over odd jobs. Road approaches can be stoned, riprap placed and gutters cobbled when the ground is too wet for setting telford. Accidents should always be so provided for that when they occur they do not stop progress. For example, the work should be so arranged that if the quarry fails, the teams may be put to use at grading or hauling other materials.

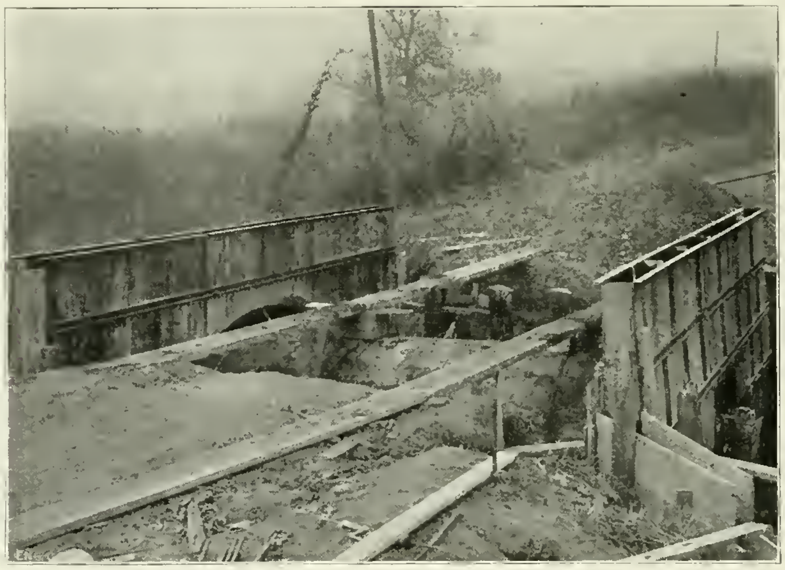
Thorough inspection and efficient superintendence are essential. The inspector can, by exercising his common sense, bring about a considerable saving in expense and at the same time accomplish all that the specifications require, viz., a satisfactory road. The superintendent should be on the work at all times and should always have the work planned ahead. A part of the function of the inspector as well as the superintendent is to give advice during construction as well as to criticize after completion.

Experiments have recently been carried on in Germany for the use of the Arzolla water plant in order to exterminate mosquitoes. Regarding this a recent consular report states that the director of fisheries at Biebrich, Mr. Bartmann, has, after experiments covering a period of 14 years, found that the most reliable means against mosquitoes in stagnant waters is the growing of the various kinds of the semitropical plant arzolla. Experiments were made at Wilhelmshaven which possesses a malaria station, and is in a territory full of stagnant waters and swamps, infested with mosquitoes. While the proximity of the sea and the abnormally cool temperature of the summer of 1907 had an unfavorable influence upon the growth of the plant, it, however, covered the experimental waters in a short time, with a layer of about 6 centimeters (2.362 ins.), which suffocated all the mosquito larvæ below and prevented the living insects from depositing their eggs in the water. The final official findings of the experiment will soon be announced. It is, however, reported that a strictly scientific and practical proof has been made in the laboratories. Director Bartmann several years ago communicated his method to the mosquito-destroying commission at Eltville on the Rhine.

A Steel Form for Arch Culverts and Highway Bridges.[*]

BY C. F. SCOTT.[†]

This paper describes a steel form for arch culverts and bridges. These forms are made of sheet steel connected with channel and T-bars by means of 5/16-in. button-head stove bolts. The sheets at retaining or end walls are connected by means of channels running the entire length of the wall, while the sheets over the arch are connected and supported by means of T-bars to the proper radii. The rigidity of the sheets themselves, together with the channels at retaining walls and the tees under the arch, eliminate the need of any bracing other than the bolts that are used to hold the channels together in retaining walls. The form set up in place is a bridge in itself, with practically the same effective area of waterway as the finished bridge.



Steel Form for Arch Culverts in Place.

The superstructure for this form consists of ribs of T-bars, making the span in two pieces that are coupled in the center by a fish plate. This joint is wedged apart by means of a cut nail driven between the tee ends for the purpose of affording slack by drawing out when the from is to be taken down. As soon as two of these ribs have been coupled up and placed, the first arch sheet is bolted on, after which the form is self-supporting. Other rib arches and arch sheets are simply bolted on until the form is set up. This work goes on very rapidly as the man on the outside places the sheet and inserts the bolt, and the man on the inside turns the burrs on by means of a socket wrench in a carpenter's brace. The arch sheets used are No. 12 gage steel, all punched carefully to a templet so that they will fit exactly either side up, either side out, or either end to. The workman simply brings a sheet of steel that requires no fitting instead of a piece of lumber that invariably does. The retaining wall is constructed of No. 10 gage steel and channel irons stayed by means of ½-in. bolts connecting the channels at intervals of 3 ft. These bolts are pulled out of the wall when the form is taken down. All arch sheets are exactly 8 ft. long and 2 ft. wide. The sheets for retaining walls are 10 ft. long. All sheets are alike except that the arch sheets that join the retaining walls are shaped so as to provide for the necessary batter of retaining wall, and the retaining wall sheets that abutt the arched portion which are cut to correspond to the radius of the arch. These particular sheets belong to that particular size bridge form, as do the iron ribs. All other sheets and parts may be used in any other sized bridge.

These sectional forms are prepared so as to construct arches of any span from 5 ft. up, in multiples of 5 ft. One of these forms may be used for an indefinite number of times and always be as good as new, while it is impossible to use lumber more than three times with any satisfaction, no matter how good the quality, or how painstaking the gang.

Steel forms of this type are lighter than the material necessary for a wooden form for the same size bridge. The form for a 15-ft. arch complete with end walls, bolts, and all weighs about 800 lbs., and can easily be hauled in two loads, while the material for forming the same bridge in lumber weighs about twice that amount.

To erect a steel form for the ordinary culvert and small bridge—say a 15-ft. span, elliptical arch—but two men two days are required. These two men are simply good, honest workmen who know how to hold a wrench or turn a screw driver. The expense will not exceed $10.

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[*] Prepared from a paper presented to the National Association of Cement Users and from additional information secured from the author.

[†] Princeton, Ill.

Experimental Roads in Minnesota; Sand and Sand Road With Sawdust.

In several portions of Minnesota there is considerable difficulty in obtaining suitable material within economical hauling distance. In the Red River valley where the soil is a heavy gumbo clay, sand and gravel are only obtainable from the ancient beaches of Lake Agassiz, with the exception of occasional deposits of limited extent. Under the authority of the State Highway Commission an experimental road was built in the vicinity of Crookston in Polk County in 1906 which has proved a valuable object lesson and has demonstrated the fact that roads consisting of gumbo clay may be successfully constructed, and if properly maintained will prove in every way satisfactory and economical.

During the year 1908 the Commission authorized the expenditure of a suitable amount to demonstrate the practicability of constructing roads throughout the sandy portions of the state, by the introduction of suitable vegetable matter into the soil. The materials selected for this purpose were white and yellow clover, rye and rye straw, and sawdust. The method of application is described in the annual report of the Commission, and the matter that follows has been taken from that report.

Experimental Road of Sand.—There was selected for this experiment a mile of road, being part of State Road No. 7 in Sherburne County, commencing one-quarter of a mile south of the north boundary of the county, which is also the south boundary of the Village of Princeton, and running thence south.

The grade was practically level and the material fine sand. The work consisted in plowing up the entire width of the road except a strip 3 ft. wide on each side adjoining the road limits. All brush was removed, but trees 3 ins. in diameter and over were allowed to remain.

A strip 20 ft. wide through the center was devoted to road purposes, and the balance of the 60 ft. planted with yellow and white clover mixed with rye. The surface of the roadway proper was then covered with rye straw about 3 ins. in depth spread uniformly over it and in the work of maintenance continually raked into the ruts.

Owing to the lateness of the season when the clover was planted very little benefit has been received from that part of the experiment, but it is intended to cut this growth two or three times each year and rake it over onto the roadway.

Although only a few months have elapsed since the work was completed it has been the subject of a great amount of complimentary notice, and the State Commissioners' office has received requests to have the work continued as far as possible.

It is evident that in the sandy portions of the State where stone, gravel and clay are lacking or at least are only to be found at points several miles distant, something must be used as a substitute until such material can be discovered or produced within economical hauling distance, and the Commission believes that the introduction of this clover with the sand will soon so change its character that it may be worked successfully with our ordinary road machinery.

The Commission considers it strongly advisable to continue this experiment for several years, and has made arrangements to keep the road properly maintained.

The cost of the work was as follows:

Grading, clearing and turnpiking one mile, contract	$151.00
Seed and planting	13.88
Superintendence	15.00
Total cost	$179.88
Maintenance to Oct. 31, 1908	$ 14.00

Sand Road with Sawdust.—This road was constructed commencing at the easterly limits of the Village of Cambridge in Isanti County and running thence east on State Road No. 2 of Isanti County. The surface was practically level, and the soil a light sand.

The roadway, 25 ft. in width, was uniformly graded and a strip about 15 ft. in width covered with sawdust from mixed timber. The total length so improved was one-fourth of a mile, thickness of sawdust 4 to 5 ins.

Arrangements were made with a man living in the vicinity to go over this road occasionally and keep it raked over.

The work was not done until August, 1908, so there are no results to report at present.

The work cost as follows:

Dressing roadbed	$ 9.50
Sawdust, 303 c. yds., 91 loads, at 15c.	13.65
Hauling one mile and spreading	49.70
Total cost	$72.85

Cost per mile, $291.40.

Approximately the same results are expected from this experiment as from that on the sand road previously described.

Over 40 per cent of the ties recently purchased by the railroads of the country are oak, according to latest statistics of United States Forest Service. Cross-ties of Southern pine formed somewhat less than 25 per cent. Douglas fir ties ranked third, with approximately 10 per cent of the total.

Official statistics on German shipbuilding show that during the year 1908 there were 99 (against 135 in 1907) sea-going steamships, of an aggregate of 117,270 gross register tonnage, built in German shipyards; at the close of the year 67 ocean steamers were in course of construction, representing 187,362 tonnage.

Notes on the Maintenance of Macadam Roads.*

The maintenance of macadam roads is the most important work of a road system and should be closely looked after by intelligent and expert men. Especially is this true under motor traffic. The roads should be divided into sections and a man kept constantly on each section with such tools and materials as may be necessary to repair a break in the macadam as soon as it appears and to keep clean all ditches and drains. He should go over his section at least twice a week and after each rain. If a rut or hole should appear in the macadam surface, showing signs of mud or a weak foundation, he should dig out the macadam, remove the mud or unstable foundation and refill the hole with stone, thoroughly ramming each course until it is solid and even with the adjoining surface. Wetting the screenings will greatly assist in consolidating and cementing the patch.

Where a rut or hole appears and does not show any signs of a weak foundation and mud is not coming up, it will only be necessary to loosen up the macadam for a short distance beyond the rut or hole, and apply just enough stone after they have been thoroughly rammed to bring the surface even with the adjoining surface, and apply the dust as above. The size and kind of stone should be the same as used in the macadam.

The application of a thin coat of coarse sand will preserve and greatly prolong the life of macadam subject to heavy motor traffic, and will also prevent a lime stone binder from becoming sticky after a thaw.

One thousand pounds of old French scrap have been forwarded to the Director of the United States Mint at Philadelphia by the Chief Quartermaster of the Isthmian Canal Commission to be used in making Canal Medals. Up to Jan. 1, 1909, about 2,100 medals have been earned, and it is estimated that the number of medals to be earned in the future will aggregate about 500 per annum. In the distribution of the medals the following method will probably be observed: Medals which have been earned by persons no longer connected with the Commission or Panama Railroad Company will be distributed from the Washington office of the Commission; medals earned by employes who have died subsequently will be delivered to their heirs, and medals earned by present employes will be distributed from Culebra.

Fourteen of the largest automobile works of Germany and France, according to a recent consular report, have come to an agreement not to participate in any racing or competitive contest during 1909. The penalty for violating the agreement is fixed at $20,000.

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*From the annual report of Henry G. Shirley, Road Engineer of Baltimore County, Maryland.

Unclassified and General Articles

Note: This section is devoted to methods and cost articles on construction work not properly coming under any of the preceding classifications.

"Little Hints" for Ambursen Helpers.[*]

THE AMBURSEN DAM is the best kind of a dam that has ever been built. It is the strongest, most economical, most rapid in construction and best suited for all conditions of service. GET THAT INTO YOUR SYSTEM.

* * *

The Ambursen Company stands for a "square deal." It plays the game with the cards upward on the table. There is nothing concealed, no secret commissions, no mental reservations. *"This is the first and great Commandment."*

* * *

The habit of getting everything packed and ready for a quick scoot when the whistle blows does not mean a "raise" for you. Work as if you owned the firm—you may some day.

* * *

Be peculiar, and when you come to your work, *go* to work even if it is five minutes ahead of time. This habit shows the difference between the man who is going to be a manager and others who have no luck.

* * *

Be careful never to leave oily waste anywhere about. Spontaneous combustion is a common cause of fire.

* * *

Estimates of cost are never to be given by *any* one under *any* circumstances at *any* time without first consulting the Boston office.

* * *

Don't use the telephone for gossip. Never lose your temper at the telephone. Telephone courtesy is a great thing. Courtesy always is.

* * *

Place your construction telephone so that a person using it can look out on the work while waiting.

* * *

All employes about the work should be dignified in deportment and attend strictly to business. They should never be seen hugging, wrestling, tripping or jollying. These things all make a bad impression.

* * *

Do not run down rival concerns—do not run down other designs of dams. We have the *best*. That is sufficient. If you do not know what to say—say nothing.

* * *

To repeat an unkind remark is as bad as lying.

* * *

Frequent meetings of department heads and meetings of all workers who have authority on any job are good things. You cannot afford to cut them out.

* * *

Avoid cliques and do not gossip or listen to gossip about your fellow workmen.

* * *

The sanitary condition of your construction camp is of extreme importance. Every precaution must be taken against epidemic. Daily inspection is often necessary—weekly inspection an absolute necessity.

* * *

Enthusiasm is the best lubricating oil to make construction wheels go round. A grouch is like sand in the bearings. Enthusiasm is catching.

* * *

Do not join the Knockers' Club. Beware of the Anvil Chorus. You cannot build dams by talk and perhaps the other fellow is a better man than you are after all.

* * *

Shed no tears because you did not have advantages early in life. No really great man ever had any advantages unless he made them himself.

* * *

Date all your letters—memorandums—calculations. The dating habit is a good one.

* * *

The Ambursen Company has been in existence only four years: it has built over thirty dams.

* * *

The savings bank habit is a good habit. It is not so costly as the cigarette habit.

The man with the savings bank habit is the one who never gets laid off. He is the one who can get along without the firm but the firm cannot get along without him. The savings bank habit means sound sleep, good digestion, cool judgment and manly independence. It is the most healthy thing you know. It is a guarantee of good behavior.

* * *

Blow one whistle five minutes before starting time.

Two sharp whistles at starting time.

One whistle at closing time.

Three long whistles for blasting.

Repeat blasting whistles twice before firing.

Three short, sharp whistles just before the shot.

* * *

Don't throw waste paper and refuse on the floor—baskets are provided.

* * *

Changes from original plans and specifications will not be permitted. If owners request it see that the order is given in writing to you and immediately inform the Boston office. If you insist upon this rule it may cause temporary friction, but it is best to have a battle *before* the expenses occur—not *afterwards*. No exception should be made in favor of any one.

* * *

Be circumspect and courteous. Bear the faults of some, the impoliteness of others and find some excuse for everybody except yourself.

* * *

The carpenter with the best tools should be given the preference on all work if other qualifications are equal.

* * *

Look out for graft. Be it large or be it small it means "skidoo" for any man who indulges in it. "You cannot fool people all the time."

* * *

THE POLICY OF THE AMBURSEN COMPANY is—the best work will in the long run bring us the most profits, the great success, the most intense satisfaction.

* * *

Keep away from gambling rooms, pool rooms and places where you would not care for your employer to see you—or to have you see him.

* * *

The owner's interests require that the work be executed in the shortest possible time, at the lowest possible cost, of the best quality of workmanship. The owner's interests are *your* interests.

* * *

The habit of borrowing small sums of money in advance of pay day is a bad practice. It breaks many friendships. You show no kindness in loaning money to one who is always borrowing.

* * *

If you encounter rudeness meet it by patience and politeness—it makes you feel better.

* * *

The owner knows what our profits are from the very outset of the work. You cannot save anything to the owner or to us by producing cheap, slovenly results.

* * *

Give every customer your whole attention—be just as considerate to the owner of a small dam as a large one.

* * *

Speed is more often secured by effective organization than by crowding the work with a large number of men.

* * *

To jolly visitors or give short, sharp answers even when talking to stupid people is a great mistake.

* * *

Address all communications to the company direct—they will then receive attention and not be treated as personal mail.

* * *

Concrete foremen, carpenter foremen and all other foremen on the same work should go out of their own way to accommodate each other. Co-operation means success. Do not strive for individual records. Organize for team work.

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[*] A pamphlet issued by the Ambursen Hydraulic Construction Co., 176 Federal St., Boston, for the guidance of its employees.

* * *

Learn from your mistakes but don't cry over them. Every one makes mistakes. We redeem the past best by forgetting its troubles and by profiting by its lessons.

* * *

No superintendent should permit subscription papers to be circulated for presents for *any* one. This is a very insidious form of graft.

* * *

Read the advertisements sent out by the the company. If you cannot get them they will be sent upon request. Without "butting in" find out what all our departments are doing.

* * *

Fly a red flag from your dynamite box by day and hang a red lantern there by night. Never store exploders near powder.

* * *

The dams we have built during the past four years aggregate two miles in length, their combined "deck" or surface exposed to the water is over 250,000 square feet.

* * *

Do not work for any individual. Work for the DAM,—never try to gain favor with one who seems to have influence or "pull." Work for the DAM. Don't make "grand stand plays" to advance your individual record. Work for the DAM. Your record will take care of itself.

* * *

Are you working too hard? (rats!)

Cold feet, lame back, lazy Dagoes, rivers in flood? (come off!)

Graft knockers, lies, pull, cheap competition? (forget it!)

We are making touch-downs, boys. That's the point. No one can beat our record. We are making touch-downs.

* * *

The most precious possession in life is good health. Eat moderately, breathe freely, exercise constantly, get eight hours' sleep.

* * *

Pile cement and lime in the store house so that the oldest will come out first.

* * *

Do not touch pencils, papers, pens, erasers on another man's desk. Remember the Golden Rule.

* * *

Foremen and timekeepers must always report to the superintendent before *starting* or *leaving* work.

* * *

There are valuable positions opening up in every progressive concern. Be ready to be promoted. Promotions go straight to the cheerful and intelligent worker.

* * *

In writing letters never show resentment or anger. The letter lives after the offense is forgotten. Do not write to a friend any criticisms regarding the firm. To give the firm a "grand call down" and then post the letter in the firm's envelope is a grave error. It may be misdirected and would surely come back to the head office. A better rule is to never give the firm a call down—to any one except the firm.

* * *

Do not argue with owners or engineers nor contradict them.

* * *

Get from foremen and workmen names and addresses and send them to the office for record provided they are good men for us to use in the future.

* * *

Responsibilities gravitate to the man who can shoulder them and power comes to those who know how.

* * *

If the owner or his engineer find fault unnecessarily—forget it.

* * *

Fall in love with your Dam and keep in love with your wife. This means progress and a happy home.

* * *

The Ambursen Company has never built a dam that was not a success both in design and construction.

* * *

Don't put letters or memorandums under blotters or in drawers or in places where people cannot find them. Put them on your desk under a weight, then if you never come back to the office the business can go on just the same.

* * *

Keep constantly before you the "*Value of Time*." "We take no note of time but by its loss." TODAY is the accepted time. TODAY is all there is. Put it to its best use.

During January the seven track shifting machines in the Central Division of the Isthmian Canal moved a total of 527,171 ft. or 99.8 miles of track. In the Tabernilla District track shifter No. 5 moved 116,800 ft. or 22.1 miles. At San Pablo and Caimito, shifter No. 5 moved 67,310 ft. or 12.7 miles. At Gorgana and Matachin, No. 7 moved 65,282 ft. or 12.3 miles, and No. 9 also moved at Matachin 46,885 ft. or 8.9 miles. At Santa Cruz, No. 1 moved 88,006 ft. or 16.7 miles. At Miraflores No. 8 moved 53,299 ft. or 10.1 miles, and at La Boca, shifter No. 2 moved 89,559 ft. or 17 miles.

The South Manchuria Ry. Co. has floated a loan for $9,720,000. The proceeds of this loan, with other unappropriated sums still at the company's disposal, will be used for the construction of the new Antung-Mukden Line, for the completion of the Dalny-Suchiatun double tracking, for the harbor works, electric railway, gas works, new shops, and other enterprises now under way or to be started in 1909, as well as for the loans to be made to the Chinese Government on account of the Hsinmintun-Mukden and Kirin-Changchun railways.

LETTERS TO THE EDITORS.

"Education of Inspectors at the Contractors' Expense."

Sirs: While recognizing that there are some stray grains of truth in the article under the above caption in the issue of ENGINEERING-CONTRACTING for Feb. 10, 1909, I cannot let pass unchallenged the author's decided implication that practically all inspectors—six out of seven groups and the seventh a small rare one to follow him more closely—are ignorant, incompetent, utterly devoid of intelligence or a sense of justice or common decency.

Without discussing the man who is "dishonest and eager of pollution," who, as the author says, may be found in any of these groups and is very satisfactory to certain contractors, it may be observed in passing that to judge from the bitterness displayed and the almost unanimous dissatisfaction he finds with inspectors with whom he has come in contact, he must have found such satisfactory ones to be very rare indeed, and such being the case his experience corroborates the present writer's firm belief.

But even the stupid incompetent, whose premeditated cussedness is such a thorn in the flesh of the innocent contractor who desires to follow his own sweet inclination without restraint, should hardly be held accountable for the shortcomings and imperfections of the specifications, in the adoption of which the inspector had not the slightest voice—even though this arrogance or the leniency or laxity of his employers permits him to assume one of the higher sounding titles. In fact, he is seldom employed until after the contract is made and entered into.

On the other hand, the contractor, being a party to the agreement, is jointly responsible for its authorship, and if he obligates himself to perform or receives pay for performing that which he knows is impossible, or that which he never intended to perform and does not perform, he is dishonest.

The plastering of exposed concrete surfaces may be very bad practice. The writer believes that it is, never allows it in specifications over which he has any control, and prefers a rough spot to a patch, but the unqualified assertion that such clauses "should always be disregarded" is a broad and sweeping statement, and falls with especially bad grace coming from the very man who has specifically engaged to do that particular thing. Supposing the modern method of separate contracts were adopted, shall the man who secures the job of plastering the exposed surfaces keep all the money or divide with the form builder and the concretor when he decides to abrogate the objectionable clause?

The contractor who undertakes to educate an inspector by the unsupported declaration that the specifications—to which he has affixed his signature and for the faithful observance of which he has given his bond—are and ought to be absolutely disregarded, however clear and explicit the language in which they are couched, need hardly be surprised to find the education of that inspector into satisfactory docility to be an expensive task. And if the same "*wiser* and *sharper*" contractor should undertake to "skin the job right under the nose" of the inspector, and *should* happen to be detected (accidents *will* occur) it is perhaps only natural that he should look upon inspectors as a class very much as convicts look upon courts.

And "*some contractors*" are on the lookout to "gobble up"—not the weakling who yields silently and timidly vacillates before bluster created by some contractor or "straw boss," but rather the stalwart chap of firmness and decision who does not hesitate to contend vigorously for what he knows to be right and who displays a commendable zeal in advancing the interests of his employers as set forth by the contract.

If the average follower of every line of activity could be assigned to his proper place in a scale of *fairmindedness* it is likely that the inspector would rank quite as high as the contractor, especially since the former has absolutely no pecuniary motive for being otherwise than just. And the sooner the contractor recognizes that the specifications are for a legitimate purpose, to be accepted in good faith or not at all, instead of in bad faith to be arbitrarily "disregarded," and brings himself to the frame of mind where he will not characterize as "mean and unfair" the inspector who will "insist upon the letter of the specification," the sooner will he find himself able to economize in the matter of "*educating inspectors.*"

Perhaps it is true that no set of specifications has ever been absolutely fulfilled, but if so, what beautiful new fields lie just before us! For surely the English language is sufficiently rich and flexible to express without ambiguity the practical and proper requirements for the prosecution of any ordinary constructive enterprise.

A fruitful source of discord is the desire on the part of the contractor that every deviation from the specifications shall be in one direction. He contracts to excavate a clearly specified material for 40 cts. a cubic yard. He finds on actually doing the work that 50 cts. would be required to pay the costs and a fair profit, and puts in a claim for the 10 cts. If the engineer is convinced that a good conscientious effort was made as likely as not the claim will be allowed. If not, he goes to court, and if the opposite party happens to be a public service corporation and he can get his case before a jury he still has a fair chance to be reimbursed for his lack of skill or judgment. But let the unforeseen conditions operate to *decrease* the cost of the work, an event which by the laws of probability ought to occur quite as often as the other, if the contractor's vastly superior judgment, keenness of observation, fundamental knowledge which is *practical* —with emphasis on it—and many generations of inherited experience are such as to entitle him to act as censor to the entire engineering profession, would he be willing to refund the extra 10 cts. when it was found the work could be done at fair profit for 30 cts.? He would probably have a stroke of apoplexy at the mere suggestion.

A specification says "one-seventh of the superficial area shall be composed of headers." The contractor, although he made no objection to the clause when he signed it, is positive that "one-eighth" is sufficient, and undertakes to "educate the inspector" accordingly. If the latter fails to grasp the lesson with sufficient readiness and requires a few yards of wall to be torn down and rebuilt according to the specifications he is "mean and unfair" and the contractor has wasted a lot of money on his education.

But he does learn in time to look through the contractor's spectacles, and next year, with the contractor's help, he draws up a set of specifications himself calling for "one-eighth of the face to be headers."

He sends out a sub-inspector merely as a matter of form, for the contractor has cheerfully signed the mutually drawn agreement and declared his intention of carefully observing every condition imposed. Imagine the sub-inspector's confusion when this same contractor starts to teach him that "one-ninth headers" is amply strong and really all that the specification intended and that the specification don't amount to anything anyway and that the inspector is mean and contemptible and unfit for the job if he makes a protest.

No, the remedy is not in ignoring or disregarding the specifications, nor "educating" the inspector to do so, but in obeying and respecting them.

And by all means let us have rational specification. Let the engineers and contractors confer one with another and discuss the specifications thoroughly before signing the contract (which is quite customary at present). Let the contractor refuse to accept any redundant, impossible, improper or impracticable clause or perhaps better, let him present his own specifications for consideration by the engineers, as many of our very best contractors are doing today. But by no means let him sign the contract until the accompanying specifications are in such form that he can fully and unreservedly endorse them and does so with the intention of honestly and completely observing each and every requirement, and has regulated his prices in conformity with that expectation.

But when his signature is affixed to the document let him consider his responsibilities just as binding as though it were a promissory note. If he has agreed to plaster certain exposed surfaces let him do so without complaining.

If he has guaranteed to furnish piles not less than 20 ft. long let him expect each foot to be composed of 12 ins.

If he has contracted to use stone absolutely free from dust let him expect it to be so as it goes into the work, irrespective of its previous history. It is not sufficient that it was clean last year over in some other state.

If the contract shows that he has agreed not to paint steel work in freezing weather, let him respect his word, however ignorant the inspector may be as to why that clause was inserted.

In short, let him change completely his attitude toward specifications, abandon his spirit of intolerance, assert his rights to consideration in their preparation at the proper time, and concede to them the respect and reverence their importance demands, instead of the scorn and disregard they formerly received at his hands; then and not until then, will the contractor have removed in large measure the necessity for "educating the inspector" with its attendant expense and contention, and have gone a long way toward securing that harmony of interest which is essential for complete success. And the very foremost contractors in this country—which means in any country—not only share these views, but are doing more perhaps than any other agency to bring about their realization. We are entering the field.

Very Truly,

C. C. Crew, Assoc. M. Am. Soc. C. E.

Bay City, Mich., Feb. 15, 1909.

Clauses in Specifications Providing for Arbitration of Disputes.

Sirs: I have been much interested in the article on "Specifications for Engineering Work" in Engineering-Contracting for Feb. 3. It recalls a case in which the writer was interested as contractor. The specifications were brief, but contained a clause that in case of question between the engineer and the contractor the matter should be referred to two arbitrators, named in the contract, one by each party. If necessary the two might choose a third and their decision was to be final. Payments were to be made on the work on the completion of each mile, the referees to examine and report to the corporation whenever a payment was asked for, and the plan worked satisfactorily.

Another fact recalled by your criticism of the day's work system adopted by the government on the Panama Canal is that the work under the contract referred to above cost the corporation less than 60 per cent of the amount spent on the first part of the work done under the supervision of a general superintendent and several assistants. Respectfully yours,

Wm. Minto.

Berkeley, Cal., Feb. 7, 1909.

Proposed Plan for Excavating for a Building Site By Power Scrapers.

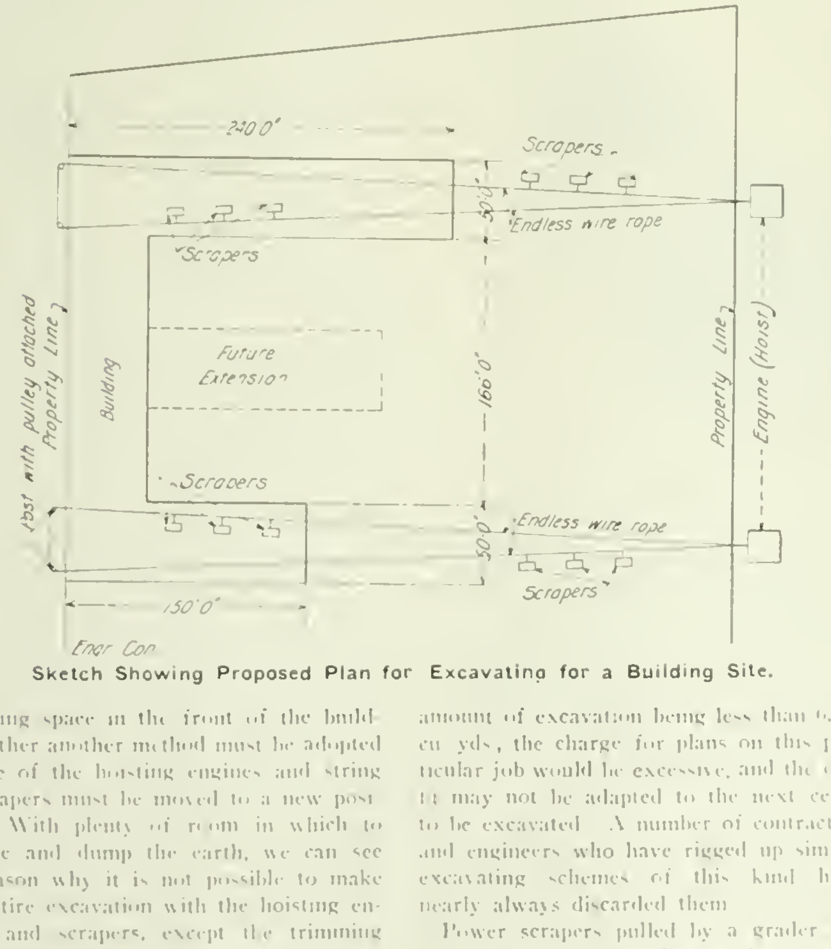
Sirs—In connection with the earth excavation of a U-shaped building we propose to employ a two-drum hoisting engine with dump scrapers attached to wire rope.

The enclosed sketch indicates the building and property with proposed location of engines. We thought of having at least three dump scrapers on each side, making six on each engine. Three filling and three dumping. The earth excavation is from four to six feet deep, and earth must be deposited on property unoccupied by building.

We would like your opinion as to feasibility of the scheme and also suggestions. What would be the best type of scraper?

Byers and Anglin.

Montreal, Jan. 25, 1909.



Sketch Showing Proposed Plan for Excavating for a Building Site.

[For the two ends of the building, the method suggested by our correspondents is well adapted, but to excavate the intervening space in the front of the building, either another method must be adopted or one of the hoisting engines and string of scrapers must be moved to a new position. With plenty of room in which to operate and dump the earth, we can see no reason why it is not possible to make the entire excavation with the hoisting engines and scrapers, except the trimming up of the cellar.

There are a number of power scrapers on the market, but many of them are meant to be used either in connection with a derrick, derrick car, locomotive crane or cableway. Among these are the Heyworth-Newman Excavator, the Austin Drag Bucket Excavator, the Page bucket, the Vivian scraper, the Ladgerwood self filling drag bucket, the Lidgerwood steam operated scraper. We have never known of any of these power scrapers being operated in pairs or in threes, as suggested by our correspondents. The only scraper that is pulled directly by a cable, of which we have knowledge, as being on the market, is the Bogley Grader. This is a power scraper of large capacity that is operated in a manner similar to the suggestion made in the above letter. This scraper, like the others mentioned, is only operated one to a cable. The McCormick Excavator, which we understand is not now for sale, but several of which have been used in the west, is meant to be operated as shown in the accompanying sketch, two or three on a cable pulled by a hoisting engine.

The experience of the writer is that that it is not advisable for a contractor to attempt to rig up such a device, especially for a small job as this. If a machine that has been tried can be bought at a reasonable price it is well to use it, but to buy the separate pieces of the outfit, the cost is generally high, and in this case the amount of excavation being less than 6,000 cu. yds., the charge for plans on this particular job would be excessive, and the outfit may not be adapted to the next cellar to be excavated. A number of contractors and engineers who have rigged up similar excavating schemes of this kind have nearly always discarded them.

Power scrapers pulled by a grader are suited for railroad grading as the cuts are narrow, and the material is dumped into long embankments and the scraper can be dumped without building a platform or runway of timbers from which to dump it, but for dumping on a level piece of ground, as shown in the illustration, some kind of a dumping platform must be built.

There are a number of methods well adapted to this class of excavation. Drag and wheel scrapers can be used. A small revolving steam shovel loading into wagons is another method. Derricks or locomotive cranes operating grab buckets, skips or some of the power scrapers mentioned above are also suited for cellar excavation. All of these methods have been tried and there is available cost data on them.—Editors.]

The Meaning of Cost Per Square Foot of Surface Contact of Forms.

Sirs—I note in your issue of Feb. 10, page 118, your answer to Mr. M. J. Danielson, which doubtless refers to the writer's paper. In answer, would say that the price of forms includes all necessary posts and staging, also wheelbarrow runs for the placing of concrete. The paper as it will finally appear in the Proceedings of the National Cement Users' Association will include a few facts which were not in the first draft and which were brought out by the criticisms of the convention and by letters subsequently received.

To obtain the amount of lumber per square foot of surface contact, the unit price of lumber in the tables can be divided by the average price of lumber per board foot, which here in the East is 2.2 cts., so that you will see that on the average less than 2 b. ft. B. M. were used per square foot.

L. C. Wason.

Boston, Mass., Feb. 16, 1909.

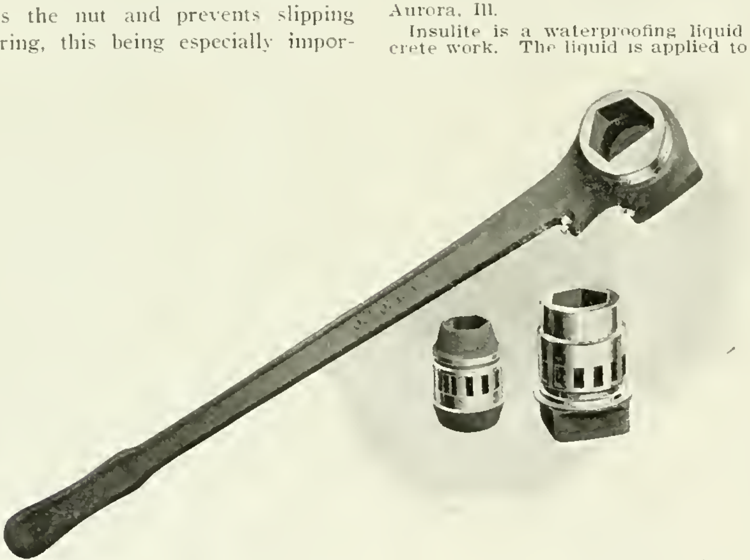
The Board of Water Supply of New York City is now calling for bids for two contracts for constructing two portions of the Catskill Aqueduct. The work consists of the construction of about one mile of tunnel on the hydraulic gradient, known as Bull Hill tunnel, 17 ft. high by 13 ft. 4 in. wide inside, lined with concrete; and two short stretches of plain concrete conduit, known as cut-and-cover aqueduct, at the ends of the tunnel, about ½ mile long, 17 ft. high by 17½ ft. wide inside, situated in the town of Phillipstown, Putnam County. The second contract calls for construction of 5,450 ft. of plain concrete conduit, known as Yorktown cut-and-cover, 17 ft. high by 17 ft. 6 in. wide and two tunnels, 17 ft. high by 13 ft. 4 in. wide, on the hydraulic gradient, having a combined length of 6,450 ft., and known as Hunter's Brook and Scribner Tunnels, situated east of the Hudson River in the town of Yorktown, Westchester County.

For the fiscal year ending June 30, 1908, a total of 59,825 applications for patents of all descriptions were filed with the U. S. Patent Office. There were 7,467 applications for registration of trade marks; 810 for labels, and 339 for prints, making a total of 8,616. The number of patents granted was 34,003; design patents, 718; reissue patents, 151; trade marks, 6,135; labels, 636, and prints, 279, or a total of 41,952. The expired patents which became public property numbered 24,270.

A Reversible Ratchet Wrench.

A new wrench, which will interest machinists, bridge erectors, contractors and others who handle work where many nuts of uniform size have to be placed, is illustrated in the accompanying cut. This wrench is made in several sizes, each with a different length of handle and each with several sizes of head. The handle is in one piece and without joints to weaken it. The reversing attachment is near the head and so guarded as to prevent likelihood of injury. The heads are made to accommodate square nuts on one end and hexagon nuts on the other, or hexagon nuts on both ends, and so constructed as to have the opening clear through the head, thus allowing the bolt to go through it and allowing a jam nut to be seated if desired. The small amount of machine work on this wrench has greatly minimized its cost.

One of the marked advantages of this construction is that the wrench entirely compasses the nut and prevents slipping and marring, this being especially important where new work is being assembled, or where nuts are being removed from cylinders to be later replaced. It is also very serviceable in limited space, as a slight travel of the handle will catch one tooth of the ratchet and cause it to work. The movement can be reversed instantly by throwing over the lever. In seating or removing nuts the motion is continuous until the operation is completed, thus greatly economizing time. The No. 1 size takes three different heads, the No. 2 can be furnished with five heads and the Nos. 2½ and 3 with three heads each, the openings of all the regular sizes being designed to fit standard nuts. One head accompanies each wrench regularly, but any or all of the various heads can be furnished according to a schedule of sizes giving detailed information and prices.



A Reversible Ratchet Wrench with Interchangeable Heads.

This wrench is made by Greene, Tweed & Co., 109 Duane St., New York city.

On Feb. 1, a total of 62,751,924 cu. yds. of excavation had been done on the Isthmian Canal.

Catalogs Worth Having.

Engineers and contractors should have on file the latest catalogs of machines, tools and supplies that they use. In sending for catalogs reviewed or advertised in this paper, you will confer a favor on us if you will write direct to the advertisers and state that you saw the catalog mentioned in ENGINEERING-CONTRACTING. If you are in the market for tools, machinery or supplies, tell us and we will notify promptly the leading manufacturers.

No. 1093.—**Shelby Steel Tubes.**—National Tube Co., Pittsburg, Pa.

This 46-page book is one of the handsomest examples of descriptive catalog work we have ever seen. Seamless steel tubing, as most of our readers know, has an extensive use for boiler work, automobile construction, and a variety of other purposes. This pamphlet describes in detail the method of constructing this tubing beginning with the rough billets and following each step to the complete tube. There are many handsome illustrations showing the methods of manufacture and the finished product as turned out for various purposes.

No. 1094. **Insulite.** National Insulite Co., Aurora, Ill.

Insulite is a waterproofing liquid for concrete work. The liquid is applied to the concrete surface by means of a brush and is of such a nature that it penetrates the concrete and closes the pores against absorption or flow of water.

No. 1095.—**Engineering and Drafting Instruments.**—Queen & Co., Philadelphia, Pa.

This is the regular 125-page catalog of the above well-known firm's list of engineering and surveying instruments and supplies. The more important instruments are fully described, and prices and sizes are given for all instruments and materials listed.

No. 1096.—**Earth - Handling Machinery.**—Western Wheeled Scraper Co., Aurora, Ill.

This catalog of 101 pages illustrates and describes the full line of earth-handling machinery made by the well-known firm named. The description of wheeled and drag scrapers is particularly complete. Among the other devices described are plows, dump cars, spreader cars, elevating graders, and dump wagons. The catalog not only describes these various machines in respect to construction, but also gives a large amouut of information as to the best methods of using them in earth work.

No. 1097.—**Crushing and Road Building Machinery.**—The Good Roads Machinery Co., Kennett Square, Pa.

This 60-page pamphlet illustrates and describes the Monarch line of road machinery, sold by the above named company. The Monarch crusher and crusher outfits are described in great detail. Among the other machines illustrated are traction engines, dump cars, road machines, and road rollers, as well as dump wagons, dump cars, scrapers and plows. This firm shows a very complete line of road machinery and the catalog should be of interest to road builders in

Personals.

Mr. James L. Tighe, City Engineer of Holyoke, Mass., has been elected a member of the Institution of Civil Engineers.

Mr. W. E. Smith has resigned as City Engineer of Webb City, Mo., to become General Manager of the Engineering Construction Co., of Kansas City, Mo.

Purdy & Henderson, Inc., Civil Engineers, have removed their offices from 78 Fifth Ave., New York City, to the Everett Building, Union Square North, that city.

Edwin Reynolds, for many years an official and consulting engineer for the Allis-Chalmers Co., of Milwaukee, Wis., died Feb. 19, after a long illness, aged 77 years.

The New York State Highway Commission has appointed the following division engineers: Harry P. Willis, Eastern Division, with office at Albany; F. W. Sarr, Middle Division, office at Syracuse; M. W. Wilbur, Western Division, office at Rochester.

Mr. Frank L. Getman, formerly Deputy State Engineer and Surveyor of New York, is now located at Havana, Cuba, where he is Office Engineer for the Cuban Engineering & Contracting Co., which has the contract for the construction of the new Havana sewer system.

Mr. Olaf Hoff has opened an office at 149 Broadway, New York City, where he will engage in a general engineering practice. He will make a specialty of the design of bridges, foundations, tunnels and subways and the organization and direction of new construction.

Mr. A. B. Lender, for the past nine years Superintendent of Erection with the American Bridge Co., of New York, has left the employ of that company and is now associated with the Merrill-Ruckgaber-Fraser Co., Contracting Engineers, 50 Church St. New York City.

The Wynkoop-McGormley Co., Toledo, O., has been incorporated by C. W. Wynkoop, Geo. McGormley, J. C. McGormley, L. N. Devore and C. S. Davis. The company will be a subsidiary concern to the Massillon Bridge Co., of Massillon, O., and will do a contracting business.

Mr. J. M. Bramlette, formerly Superintendent of the Michigan United R. R. lines in Lansing, Mich., and afterward General Manager of the company, has accepted a position as Superintendent of Construction for the Northern Construction Co. and will be located for the present at Rives Junction, Mich.

The Albemarle Construction Co., of Charlottesville, Va., has been organized with Mr. E. M. Wayland President, M. G. Homes Secretary and Treasurer and W. N. Lupton Manager, and will engage in a general contracting business, making a specialty of concrete blocks and buildings, sidewalks, retaining walls, dams, arches and concrete foundation work.

Mr. D. C. Henny, heretofore Supervising Engineer in charge of the Pacific Division of the U. S. Reclamation Service, has been given an appointment as Consulting Engineer. On Feb. 1st the Pacific Division was divided, Mr. E. G. Hopson becoming the Supervising Engineer in charge of all work previously forming part of that division lying in the states of Oregon, Nevada and northern California. Mr. C. H. Swigart becomes Supervising Engineer in charge of all work formerly in that division lying in the state of Washington.

John C. Williams, President of the Forest City Steel & Iron Co., died on Feb. 7 at his home in Cleveland, O. Death was due indirectly to a fall from a suburban car at Rocky River last September. Mr. Williams was born in Hagerstown, Md., June 3, 1830. His first active railroad work was on the first survey of the B. & O. west from Cumberland, Md. He was also instrumental in securing the right of way for the first telegraph line between Washington and Baltimore. In 1861 he first came to Cleveland and became chief engineer of the Cleveland & Mahoning, later a part of the Erie system. Later he removed to Wisconsin, but returned to Cleveland in 1861 and re-engaged in railroad work. He soon afterward became chief engineer of the Cleveland & Toledo, now a part of the Lake Shore, and was successively chief engineer of that line from Union, Pa., to Titusville, Pa., the Ashtabula branch of the Lake Shore and Mahoning road. In 1874 he was in charge of the construction of the stone work of the Superior Ave. viaduct in Cleveland. In 1880 he became chief engineer of the Chicago & Atlantic, afterward winning promotion to the general superintendency. He was at one time also general superintendent of the old Mad River R. R., which became known as the Cleveland, Sandusky & Cincinnati. He also took an active part in numerous other great railroad enterprises until his retirement about 1900.

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A Ridiculous Road Specification Which Increases the Cost of Hauling Road Materials, and a Demonstration of the Value of Cost Analysis to the Writer of Specifications.

Ten years ago the managing editor of this paper had contracts for road building in the state of New York under specifications that were seriously objectionable on economic grounds. In a series of articles, written at that time, the principle objections to the specifications were outlined and many important changes were subsequently made in accordance with the suggestions offered; but there still remains one clause which, if lived up to, adds very materially to the cost of macadam road work without adding a thing to the quality of the road produced. We refer to the clause that requires the contractor to start at the point farthest from his rock crusher, or from his supply of broken stone. By this requirement, the contractor does not haul any of the stone over any part of the macadam that is being built or has been built.

It is probable that this clause originated in Massachusetts, for the old New York State road specifications were largely copied from those of Massachusetts, just as other states have more recently copied the specifications of New York, in this fashion spreading and perpetuating an economic mistake.

What the engineer who originally prepared this ridiculous restriction had in mind, we can only guess. In all probability, however, he feared that the hauling of broken stone over a partly rolled macadam would tend to cut ruts in it, and injure the road before it had been finally consolidated by the roller. At any rate, this was the only reason that was given by the engineers in charge of the New York road work at the time above referred to. Replying to this reason, the writer urged that in the days of old John MacAdam himself there were no rollers, and that all the rolling was done by wagon wheels, and that no one denied that MacAdam had made good roads by that process, although it took longer to secure a finished surface.

Furthermore, the writer contended that any incipient ruts made by wheels in the loose broken stone could be removed by laborers using potato hooks or rakes.

The writer finally obtained permission to build a stretch of road, beginning at the rock crusher and working away from it, upon condition that any poor macadam resulting from this deviation from the specifications would be torn out and relaid at the writer's expense. The result was that three miles of macadam were laid in this fashion, and it was evident to all at the time that no better road could have been built in any other way. The subsequent durability of the road confirmed the first conclusions.

Now what is the advantage derived from starting to build a macadam road as near the source of stone supply as possible, instead of starting as far from it as possible? Simply this: The stone can be hauled over a macadam road instead of over an earth road. This enables the contractor to haul loads two to three times greater than could be hauled over an earth road, and as hauling is one of the largest items of cost in building the average macadam road, a great saving can thus be effected.

This instance of the application of cost analysis serves to show why no engineer is competent to draw a set of specifications until he has made a study of the actual detailed costs of construction. It is not sufficient that the engineer should know that 6-inch macadam can be let for 65c a sq. yd., in a certain locality, which is all that the average engineer of the old school thought it worth while to know. An engineer should know the actual cost of every item that goes to make this 65c, for he is then able to see the effect of any given clause in his specifications, and to reason whether or not it will pay to insert a given restriction. Indeed, many engineers never reason at all about the economic effect of such restrictions, until they have acquired the habit of making cost analyses of construction work.

Within the last few years, traction engines for hauling broken stone in dump wagons have been growing in popularity among road building contractors. While a traction engine is effective even on earth roads, it is far more so on hard, smooth roads, for then it more nearly approaches the efficiency of a locomotive on rails as a tool for transportation. Therefore, the engineer who wishes to encourage the use of traction engines should be particularly careful not to require that the road shall be started at the point farthest from the source of stone supply. With the more extended use of traction engines by road contractors, there will come a reduced cost of road work, in which the public will share. Also it is clear that every thing that cheapens road work adds eventually to the road mileage, and therefore to the field for engineers engaged both in the construction and maintenance of roads.

It is evident there can be no logical defense of the clause in road specifications prohibiting the contractor from using his own macadam road until he had completely finished all of it. He should not only be permitted but encouraged to start the macadam as near his supply of stone as practicable, so that he will haul all stone over the macadam he has already laid. Incidentally this hauling is itself the best test of the quality of the work he has done.

If the road stands up under it, it will stand up under the future traffic.

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Some Reasons Why the Appraisal of Railways Is Imperative if There Is to Be Government Regulation.

Five states now have some definite knowledge of the cost of the railways within their boundaries. In the order of the making of those appraisals, the states are as follows: Texas, Michigan, Wisconsin, Washington, Minnesota.

Of these states only the last two have had appraisals made for railway commissions for the purpose of using the appraisals as a basis of rate making. The other three states made appraisals as a basis for taxation or for the limiting of bond issues.

In the effort to make such appraisals unpopular, it has been urged that they can serve no useful purpose as a basis for rate making. It is held by the opponents of government regulation of railways that the value of a railway can be measured only by the service that it performs, which service has no necessary relation to the actual cost of constructing and equipping the road. We shall enter upon no extended argument to combat this theory, but shall indicate a few of the reasons why it is imperative that all railways be appraised, if there is to be any scientific government regulation of rates or of accounting methods.

To begin with, every rate making commission is confronted by the decision in the Smyth vs. Ames case—the Nebraska case—in which the Supreme Court of the United States has held that one of the essential elements of knowledge that a rate making body must possess before it can proceed intelligently is a knowledge of the original cost, plus the cost of improvements, and a knowledge of the cost of reproduction new, as well as the present value. But, even if no such important decision had been rendered, there are several unanswerable reasons why a physical valuation of every railway must be made before rational regulation by federal or state commissions is possible.

The public is entitled to protection against over capitalization of railways. This protection can be obtained only by a knowledge of the actual investment in things tangible, that is in physical property. All else is "good will," which may or may not have a value. The "good will," or "franchise value," of a public corporation certainly should be considered in regulating its charges, hence just what this "good will" amounts to is a matter of fundamental importance. Now, there is but one way to ascertain what the "good will" is really worth, and that is to capitalize the net income of the corporation and deduct there from the value of its physical property. Thus we come back to first principles—the finding out what the physical property is worth.

It is beginning to be conceded by the largest corporations that publicity is the best cure for internal evils of management. Insurance companies, banks, and railways are now required to make public certain essential parts of their accounting records. This is admittedly the first step in any sound policy of public regulation of corporations. What is the next step? Obviously to see that the accounting records that are made public are absolutely correct. But, to determine the correctness of the accounting records of a railway, it is essential that the examiner of those records shall know whether the charges to each and every sinking fund are correct or not. For example, there is a sinking fund to provide for the replacement of locomotives and cars when they are worn out. No man on earth can tell whether the millions set aside annually in such a fund are too many millions or too few, unless he knows the actual physical value of those locomotives and cars and their present condition. Thus we come again to the inevitable physical valuation of railway property. Today it is possible for a dishonest railway president to make a great show of successful management, by failing to set aside proper amounts for various sinking funds, such as funds for renewal of rails, of ties, of equipment, etc. By doing this he can "bull" the stock of his company and "unload" on the unwary public. Or he can do the reverse. He can set aside arbitrary and unnecessarily large sums for renewal and repair purposes, and create the impression that his railway is earning little or nothing. These things can be done, have been done and are being done. Nor will they ever be stopped until there is definite knowledge of the physical value of all railway property that is subject to wear, rust or rot, for without a precise knowledge of such physical values no man is capable of judging accurately whether railway accounts are correctly kept or not, or even whether a railway is correctly managed or not.

The strength of this argument would be comparatively little were the physical value of destructable property small, but it is not. Nearly all the physical property is subject to destruction, land, grading and ballast being about the only items that may be said to be permanent. Even steel bridges have a life of but little more than 20 years, due to the fact that they become too light for the heavier rolling stock that a growing traffic requires. Hence any system of scientific railway accounting can not exist without the use of sinking funds into which certain percentages of the first cost must be put annually.

To apply a percentage there must be a principle. In railway accounting there is today no principle, and there can be none until it is supplied by a physical valuation. If 3 per cent per annum must be set aside for renewals of locomotives, the question is 3 per cent of what value? The value of existing locomotives? And here we are again face to face with the necessity of ascertaining that value by a careful appraisal.

The railway papers and a large part of the daily press are repeatedly putting their ignorance, or bias, into the lime light by deriding the value of physical appraisals of railways. For example, it has even been urged that to appraise all the railways in America would be an endless task and one of enormous cost. Even with the most thorough appraisal, and where railway property has higher values than the average capitalization of our American roads, the cost of appraisal has been only $15 a mile of roadway. By dividing the railways into sections containing 3,000 miles each, under 75 competent engineers, one in charge of each section, the entire mileage of America can be appraised in twelve months' time.

In the face of such facts, it will prove idle to oppose much longer the making of a systematic appraisal of all the railways in America.

Preparatory to the rebuilding of Messina, Reggio, Palmi, Bagnara, etc., Italian cities destroyed or damaged by the recent earthquake, the Public Works Cooperative Society of Lombardy (Società Cooperativa Lombarda di Lavori Pubblici) will hold a public competition to demonstrate the relative merits of various materials and methods of work and construction adapted for use in the devastated regions. According to a Consular Report, the competition will deal especially with types and systems of construction for urban, rural, and industrial edifices least likely to be affected by seismic disturbance, but the widest latitude will be given competitors regarding their exhibits. They will be at liberty to submit designs, general proposals, reports, photographs, models, samples of materials, etc. Three prizes will be given: One of 3,000 lire ($579), one of 2,000 lire ($386), and one of 1,000 lire ($193). Exhibits must be received by the College of Engineers and Architects (Collegio degli Ingegneri ed Architetti), No. 10 via S. Paola, Milan, free of all costs, before April 1, 1909. The Public Works Cooperative Society of Lombardy reserves to itself the right of applying to its own ends, with or without modifications, any exhibits that shall receive prizes. In such cases, whether exhibits are protected by patents or copyrights or not, the society will make suitable arrangements with owners for compensation. From present indications it seems likely that steel and reinforced concrete will be widely used in the work of reconstruction and that the height of buildings will be limited to 10 meters (32.81 ft.).

The total estimated production of Portland cement in the United States for 1908 is estimated as being but 10,000,000 bbls.

Concrete and Reinforced Concrete Section

Note:—This section is devoted to methods and cost of constructing concrete and reinforced concrete structures. It will cover the selection, testing and proportioning of concrete materials; laboratory tests of concrete; concrete mixing, transportation and placing; fabrication and placing of reinforcement, and form construction and erection. It will also contain articles on new and interesting developments in the design of reinforced concrete.

The Bonding of New to Old Concrete.

BY E. P. GOODRICH, M. AM. SOC. C. E.

(Concluded from p. 115, Feb. 24.)

While the engineering periodicals have published quite a number of communications from time to time with regard to the proper points in concrete floor construction at which to stop work, still these discussions have all been of an entirely academic nature, no experiments having been made with regard to this fact, so far as known to the writer, except in the case of the reinforced concrete reservoirs for Mexico City described by James D. Schuyler, M. Am. Soc. C. E.*

"There are four reservoirs, all circular in form, and 105 m. in diameter at the top. The roof consists of a 6-cm. slab of reinforced concrete supported by radial and concentric beams, resting on cylindrical pillars of concrete, all properly reinforced.

"In the building of such a massive roof over so large an area as each of these reservoirs presents, the question of sustaining the forms during the time required for the setting of the concrete was one of the most serious problems to be solved. To build up timber supports of requisite stiffness and stability reaching from the floor to the roof, on account of the height, would have required a vast forest of timber, of little subsequent utility, and costly to erect and remove. It was finally determined to suspend the form from the tops of the columns by a series of steel I-beams of standard sizes and lengths which would have a market value for building construction of at least 75 per cent of their cost after the works were completed. But in order to place the top series of I-beams high enough to act as suspensors for the forms of the main reinforced concrete beams, it was necessary to build up the capitals of the columns to the ultimate height of the top of the roof as bases on which to rest the temporary hanger beams, and in these concrete capitals, which form the ends of four intersecting concrete beams, embed all the steel reinforcing rods [illegible] required for the concrete beams. This in effect meant the formation of the ends of the beams a long time prior to their ultimate completion. Hence to determine the effect of this composite construction of a beam with a joint near each end, upon the final strength of the beam, a series of tests were made in the Condesa testing laboratory with four full size beams reinforced as they are to be used in the roof of the reservoir. Two sets of tests were made, with two beams each, 11 and 28 days after molding. These beams were 11 ft. 9 in. long, 19⅝ in. deep, 7⅞ in. wide, with a clear span of 13 ft. 1 in. between supports. In one beam of each set, the two ends were molded two days in advance of the remainder, in the form shown by the shaded areas of the diagram, leaving a well-defined line of contact between the concrete of the ends and the central portion of the beam.

"Test A, at 11 days, was made under the following conditions: The solid beam had been molded complete at one operation, with 1:2:3 concrete, reinforced at bottom with two square corrugated bars ½ in. by 11 ft. 10 in.; two diagonals ½ in. by 15 ft. 6 in.; three oblique bars ½ in. by 5 ft. 2 in. at each end, and diagonals, from center to ends, ½ in. by 7 ft. 6 in., the metal in all being 0.7 per cent of the beam. With 3,809 kilos applied at two points at one-half meter from central axis, deflection was 2.4 mm.; with 6,185 kilos applied load, the deflection was 1.6 mm.; with 10,369 kilos the deflection was 8.2 mm., when three cracks appeared, half the depth of the beam, at distance of 1.5, 2.0 and 3 meters from one end. The final rupture occurred under a weight of 11,460 kilos.

"The second beam of the pair, molded in sections as described, showed a deflection of 2.4 mm. under 3,908 kilos, 1.8 mm. under 6,815 kilos and 8.0 mm. under 10,369 kilos, when four cracks appeared, 20 cm. long at distances of 1.5, 1.7, 3.0 and 3.1 meters from one end, all inclining toward the load. The final rupture took place with a deflection of 20 mm. under a load of 13,418 kilos without the slightest sign of weakness appearing at the joints in the concrete. * * *

"Test B, at 28 days, gave results quite in parallel with those of Test A. The concrete was the same, but the reinforcing metal was greater, amounting to 1.0 per cent of the beam, consisting of three corrugated bars in bottom, two of which were ½ in. square and one ⅝ in. square, 11 ft. 10 in. long; also two bent bars with diagonal to top at end, each ½ in. square and 15 ft. 6 in. long; three intermediate bent and diagonal bars at each end, each ½ in. square and 5 ft. 2 in. long, and two central diagonal and top bars, each ½ in. square and 7 ft. 6 in. long.

"The beams showed the following comparative results during test:

Applied Load Kilos	Solid Beam Deflection	Beam Molded in Sections Deflection
3,809	2.0 mm.	1.8 mm.
6,815	3.0 mm.	3.2 mm.
10,369	7.0 mm.	[illegible]
12,556	10.0 mm.	7.[illegible] mm.
14,742	13.0 mm.	8.5 mm.
16,929	22.0 mm.	10.2 mm.
19,018	Ruptured by compression	
19,116		12.4 mm.
21,299		16.4 mm.
22,390		Ruptured by compression

"In each beam cracks began to appear under a load of 10,369 kilos.

"In this case, also, the absence of any cracks or sign of weakness on the line of joints between the older and newer portion of the concrete again seemed to prove conclusively that there was no weakness to be feared from this composite method of molding as compared with the monolithic beams, but, on the contrary, they developed greater strength in each case."

THE WRITER'S EXPERIMENTS.

It did not seem necessary to experiment as to the necessity of a thorough cleaning of the old concrete surfaces. This requirement is so obvious that it is surprising to note the way many other constructors apparently ignore it. A number of years ago, the writer discovered the advantages of using a jet of steam for this purpose, and in the *Engineering Record* of March 7, 1907, he advocated its use and gave several other hints on concrete work. The only other engineer who has advocated it is Mr. Ernest McCullough, who writes as follows:†

"Nothing is so absolutely bad in a joint as sawdust and nothing is so hard to get rid of. Shavings and blocks of wood are picked up with rag pickers' sticks, which are pieces of wood about one inch square having a sharpened nail driven into one end. Loose gravel, etc., can be brushed out. Sawdust, however, remains. Even a strong stream of water fails to get rid of it. Live steam at a high pressure will, however, clean off the surface of the concrete to the forms. It removes all the laitance and dead cement and all the [illegible]."

The writer's experiments were of [illegible] and were arranged with the following objects in view:

(a) Measurement of actual tensile strength with five methods of bonding applied to two different kinds of surfaces and after two different time intervals.

(b) Determination of the resistance to effect of exaggerated temperature changes on samples representing [illegible] sidewalk finish, placed after a relatively long lapse of time, with the help of acid treatment, as compared with simultaneous placing of the bottom and top layers;

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* Engineering Record, March 28, 1908.

† R[illegible] Concrete, [illegible] Manual [illegible]

(*c*) Determination of the advisability of depositing concrete for a deep beam in separate layers with intervening time intervals;

(*d*) Determination of the best point at which to splice concrete floor members between successive days' work;

(*e*) Value of acid treatment in ordinary floor and walk work.

The tension tests were made on standard cement briquettes. Only 1:2 (by weight) Portland cement mortar was tested.

All specimens were cured in air only, to be more nearly analogous to practical working conditions. Splices were made after intervals of 24 hours and of 7 days. All specimens were broken at the end of 30 days. For the sake of comparison, unspliced specimens were molded and broken after the same period. One series of briquettes was made and broken after 24 hours. The half briquettes thus obtained were utilized in one series of experiments, half of them being spliced after a lapse of 24 hours and the other half after 7 days. It was considered that these series would represent conditions when the surface of old work was entirely broken away and all loose material removed just before the new material was deposited. Another series of briquettes was molded with a thin strip inserted at the smallest section. When removed from the molds, of course, these briquettes fell apart into two pieces, the surface next the partition having the exact appearance of having been molded against a common wooden form. After 24 hours, and 7 days, these half briquettes were spliced, the surfaces to be bonded first being indented with a sharp steel tool in just such form as would be given with a pickaxe or blunt chisel, according to the usual methods of roughening surfaces to be joined. Five methods were used in making bonds, or rather in connection with the making of the bond:

(*a*) The soft mortar was molded against the half briquette with only as much manipulation as is usual in depositing concrete work. The old half was used dry in its natural state.

(*b*) The old half briquettes were first soaked in water for about 10 minutes and then the new end was molded as in (*a*).

(*c*) A creamy mixture of neat cement was prepared, and the ends of the half briquettes were dipped in it. This formed a coating similar to that most often specified and used. The new ends were then molded in the usual way, before the grout had set to any great extent.

(*d*) The ends of the old briquettes were liberally washed with a 1:10 solution of commercial hydrochloric acid. They were then washed in clear water to remove all unspent acid, and the new ends were molded as usual.

(*e*) A solution of "Bonsit" (a powder similar in nature to "Ransomite") was prepared in accordance with the directions sent with the can, or at the rate of 5 lb. of the powder to 10 gal. of water. This solution was then used in the same manner as in (*d*).

Three specimens representing each age, type of surface, and method of bonding were prepared.

Mortar specimens were decided upon, because it was believed that it is the mortar which has been flushed to the surface and against the forms on each side of the joint, which is the real bonding medium.

Briquettes were used for several reasons:

(*a*) Measurements of the true tensile strength of the bond could be most easily obtained.

(*b*) With the small size of the specimen it was thought that one would be more likely to obtain more uniform results than with specimens of larger size.

(*c*) If good results could be obtained with small specimens, a standard would be provided to be applied over larger areas.

There may be some question as to the truth of Assumption (*b*), because, over large areas, local deficiencies would be merged with strong sections, so that a somewhat smaller variation would probably be obtained. The actual wide variation, in some cases, is instructive as to the probable conditions at different points in any joint. The narrower range found with some methods of bonding demonstrates, if anything at all, that it is possible with them to gain a better distribution of stress over larger areas than with the other methods.

The powder when put into solution gave a white precipitate when tested with barium chloride, showing that the acid in this case is sulphuric.

The results obtained from the tension bonding tests are contained in Table IV.

While the results in Table IV are not as concordant as might be wished, still certain deductions may safely be made:

(*a*) The best results were obtained with surfaces having the roughness produced by the natural fracture. This points toward a purely mechanical bond, or one with little cementitious action.

(*b*) Practically no bond was obtained on surfaces which were molded against forms and had dried for 7 days. This is shown by the large percentage prematurely broken, even with careful handling, and the relatively low results obtained at best. Thorough soaking of the old work is essential.

(*c*) It was noted with regard to the 7-day, smooth surface, grouted bond, that the water was absorbed so rapidly from the grout as to render it an actual detriment. However, the results obtained with regard to the 24-hour and 7-day, rough surface, soaked, specimens might lead one to infer that there is a possibility of using too much water. This latter may be the case in laboratory work, but, in the writer's building experience, few laborers have ever been met who were prone to use water to what seemed an excess. In applying stucco work, or lining reservoirs, however, an expert workman knows that there is a real possibility of too completely saturating the old work, and it requires long experience and great care to obtain exactly the proper humidity.

The use of dry cement sprinkled over old concrete surfaces which have first been dampened is of questionable value, in view of the writer's experience.

(*d*) A coating of grout is advantageous, first having soaked the old concrete thoroughly to prevent the water in the grout from being absorbed too rapidly.

TABLE IV.—GOODRICH BONDING TESTS.

	Rough Surface.				Smooth Surface.			
	24 Hours.		7 Days.		24 Hours.		7 Days.	
	Each.	Average.	Each.	Average.	Each.	Average.	Each.	Average.
Plain	161 C 92	126	285 313 343	314	162 205 80	149	C H 15	15
Soaked	H H 60	60	138 218 212	189	165 90 208	154	H C 44	44
Grouted	380 315 C	347	347 280 200	276	98 43 160	100	H H H	...
HCl	68 C 155	112	126 175 221	174	87 232 105	141	83 51 44	53
"Bonsit"	30 60 H	45	152 105 95	117	79 54 68	67	172 26 114	104
Average	147	...	207	...	122	...	69	...
Whole Briquettes. 363 384 309 438 415 304 427 Av. 377								

H = Broken while handling before expiration of 30 days.
C = Broke in testing machine while adjusting clips.

(e) Acid treatment at an age of 24 hours is not of appreciable value.

(f) On surfaces originally molded against forms, after having dried for 7 days, acid is advantageous.

(g) Results with the use of acid were more consistent among themselves than with any other method.

(h) Why the splices made after the 7-day interval are so much better than those made after 24 hours on the rough surfaces, is difficult to explain, unless it be that the breaking to obtain this rough surface had loosened many small particles which still clung to the damp surface while only 24 hours old, but which were naturally removed during the handling incident to the 7-day tests.

(i) The bonds secured on rough and smooth surfaces after 24-hour intervals are not materially different.

While the acid treatment does not give a bond as strong as when the old surface is rough-pointed, still its cost is much less, and where an absolutely monolithic condition is not essential, but where fairly good bond is required, the use of acid is of value.

Again, where proper reinforcement is provided across joints, the use of acid is advisable and sufficient.

The powdered material is much more convenient to handle than the commercial acids shipped in glass carboys.

In view of the writer's and the other bonding experiments quoted, the following may be given as a proper mode of procedure:

"For connections made after a lapse of 24 hours or more, break back the surface concrete to firm material, and clean the fresh surface with steam, air blast or forceful water streams so as to remove all fine loose material. Saturate well, but not so that water stands on the surface or oozes from the material. Paint completely with neat cement grout, mixed to the consistency of thin cream, just before new concrete is deposited, and see that the latter is of proper mixture, containing a proper proportion of mortar, which should be worked against the joint so as to be certain that no voids exist in its vicinity.

"For connections made after long intervals, so that the old cement has set hard, and where the expense of rough pointing the whole surface is greater than is required because of the nature of the desired bond, use commercial muriatic acid, diluted with clear water, 1 to 5, or the commercial bonding powders, dissolved in clear water at the rate of 5 lb. of powder to 10 gal. of water. First wet the old concrete surface with so much water that a fresh wetting is not immediately absorbed. Remove any excess of moisture and when the surface appears as if commencing to dry, paint on the old surface three successive coats of acid one after the other. Let this remain for about 30 minutes, after which carefully clean the surface of unspent acid, soluble salts and fine material, with plenty of water, finally cleaning with a steam jet or air blast if obtainable. Just before the fresh concrete is to be deposited, and while the old material is still very damp, apply a thin coat of neat cement grout mixed to the consistency of thin cream, just before the new concrete is deposited, and see that the latter is of proper mixture containing a proper proportion of mortar, which should be worked against the joint so as to be certain no voids exist in this vicinity."

A block representing a small section of a concrete sidewalk, or floor, was also prepared. It was just of a size to fit a furnace door under a high-pressure steam boiler. The concrete base was molded 3 in. thick, in two operations, each covering half the area of the block. Reinforcing rods were left protruding from the first part deposited, so as to cement it firmly to the second one. The latter was placed 7 days after the first one. The surface of the latter was prepared to receive the finish coat by applying a solution of "Bonsit," according to the specification previously given. As soon as the concrete of the second section had partially set a ½ in. coat of 1:3 cement mortar was spread over the whole area of the block and well troweled so as to secure as good a bond with the backing as possible. The whole was allowed to set for 30 days, and was then subjected to an alternate heating and cooling by being placed first in the furnace door for a few minutes and then allowed to cool in the outdoor air. These alternate periods of heating and cooling were as follows:

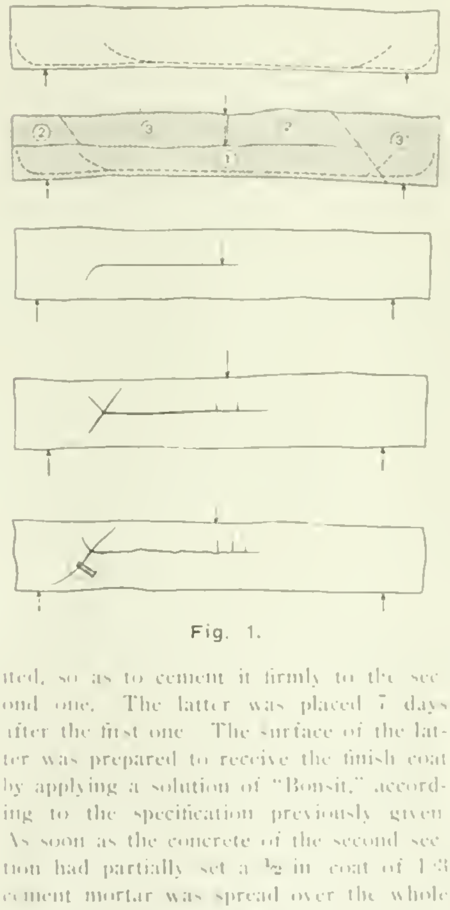

Fig. 1.

Heated 12 min.
Cooled 13 min.
Heated 15 min.
Cooled 35 min.
Heated 5 min.
Cooled 11 min.
Heated 7 min.
Cooled 15 min.
Heated 5 min.
Cooled 15 min.
Heated 10 min.
Cooled

The temperature of the mortar face (the one toward the fire) was allowed to rise until steam was seen to issue from the edge of the block between the mortar and the concrete. The temperature at the depth of the joint was then approximately 200° F. The exposed face was much higher, while what would be the bottom of the floor or sidewalk was not more than 60° F. when tested by the hand. The block was then removed from the fire and allowed to cool until the hand could rest comfortably upon what had been the exposed face. This would correspond to a temperature of about 120° F. The heating operation was again repeated, the time of exposure again reaching a point where steam appeared. After the second heating, the back of the block reached a temperature which was just a little too hot for the hand. At each cooling this fell to about 120° F., but at the same time the mortar face must have had a range of temperature of at least 100°.

After the second heating, a minute examination of the edges disclosed a hair crack along the joint between the two layers of the oldest and the newest materials; when the block had cooled so that it was about ready for another heating, a fine crack was also observed across the top along the line between the two parts of the backing. Evidently, a separation would have taken place except for the reinforcing bars. This crack could not be found on the bottom of the block, and it closed up entirely during each heating, appearing again during each successive cooling.

After the third heating, a narrow strip around two edges sounded hollow when tapped with a hammer. After each successive heating and cooling, this hollow area increased somewhat until, after the fifth heating, it included about half the area over the older section. After the final heating, however, when a hammer was used to break away the loosened surface coat, not more than two-thirds could be thus loosened, some parts carrying off adjacent portions of the backing. That portion in which the top and bottom were placed at the same time could not be separated with a clear plane of cleavage, even after the specimen was broken into fragments. In the latter condition the two parts of the other half of the block readily parted under a smart blow. However, from the writer's experience, and from a study of the conditions of the test at the site during its progress, it can be positively affirmed that the value of the acid treatment was demonstrated by the adhesion still remaining even after the repeated heat applications. No physical or weather conditions are ever as severe as those provided in connection with the furnace, and, even if each heating and cooling might be likened to an annual experience, ample bond remained after five summers and winters to warrant a contractor's guaranty, if the whole bonding operation were faithfully executed. Under actual weather conditions, the changes of temperature are not nearly as sudden or widely varying, so that the effects of the slightly different coefficients of expansion are very small.

On the basis of coefficients of 0.00000655 and 0.00000795 for mortar and concrete, as given by Bonniceau in "*Annales des Ponts et Chaussées*," and with a temperature difference of 100° F., there would be a difference of only 0.00000140 for each degree, or 0.000140, so that in blocks 100 in. square, in which the maximum probable action would be more than 50 in., the difference would be only 0.007 in. On the assumption of a modulus of elasticity of 2,500,000, the resulting tensile or compressive stress (ignoring any reduction in amount due to resulting strains) would be only 3½ lb. per sq. in. if uniformly distributed, or at that rate if concentrated at any one or more points. Whenever the bond becomes broken it must therefore be concluded that it was not sufficiently strong to withstand a shearing stress between the top and bottom layers of the amount thus computed. When it is recalled that such shearing stresses should be much more than equal to corresponding tensile ones, the inadequacy of much work is apparent, and the tests of the tensile strengths developed by the various methods of securing a proper bond tend to prove that a sufficient bond can be secured in floor and sidewalk work with proper workmanship, particularly if some special method like the acid treatment is used, in the very execution of which a sufficient number of special precautions are added to improve the result perceptibly.

The final experiment consisted in the fabrication of a reinforced concrete beam, doing the concreting in sections, each succeeding part being deposited after a lapse of about a week from the last one, while the beam was tested after a final lapse of only two weeks after the last section was concreted. The several parts and the order of deposit were as shown in Fig. 1. The mixture used was 1:2:4 (by weight), the broken stone being the run of the crusher, up to ¾-in. One of the bonding powders (Bonsit) was used to better the connection between successive parts. The beam was tested, on a 6-ft. span, with a center load, the first application, up to 2,500 lb., being applied at the neutral axis on two projecting rods which were cast in the beam for the purpose. The concrete section was 8 by 4 in. over all, reinforced with two ½-in. smooth round rods placed ½ in. above the bottom of the beam, each one extending from one end to a point about 1 ft. from the other point of support. Each end was bent upward in a comparatively large-radius turn, the one at the end through an angle of 90° and the other one through about 45°, so as to serve to some extent in resisting diagonal tensile stresses. The reinforcement aggregated 1.34 per cent of the effective beam area. The beam weighed about 180 lbs. The load was applied in increments of 500 lbs. each, the effect of each being carefully noted.

The shapes of the sections were determined with the following objects in view:

(*a*) To determine the effect of a horizontal joint in a beam, even when bonded as well as possible, where no steel is used for the purpose, when the load is applied at the level of the joint. This is the condition which exists in beams which are designed to be as deep as the distance between vertically adjacent window heads and sills in a concrete building, and where the concrete is almost invariably deposited in two separate operations, with the joint between them occurring at the level of the concrete floor.

(*b*) To ascertain whether it were possible to secure, along surfaces theoretically close to those on which maximum diagonal tensile stresses are developed, a bond of sufficient strength to make it unobjectionable to stop work along such a surface.

(*c*) To ascertain whether there is any virtue in leaving a joint only along a surface theoretically closed to those on which maximum diagonal compressive stresses are developed.

The test results obtained were as follows:

(*a*) At 2,500 lbs., applied at the center, a horizontal crack appeared, extending from the load toward one end and turning sharply downward into the mass concrete close to the turned-up end of one rod

(*b*) The load was then shifted to the top of the beam, whereupon the horizontal crack disappeared entirely and the diagonal one was barely visible.

(*c*) At 1,500 lbs., applied on the top, a condition almost identical with (*a*) had been reached.

(*d*) At 3,500 lbs. the diagonal crack had extended downward and was following along the reinforcing rod toward the end of the beam. Very small tension cracks had appeared in the upper part of the beam under the load, and a wedge-shaped piece was commencing to crack out at a point where the diagonal and horizontal cracks intersected, in the vicinity of, but not along, an artificial joint parallel with diagonal compression planes.

(*e*) The load gradually fell to about 3,000 lbs., as more strain was produced, and all these cracks became more prominent, until a sliver of concrete was forced off, revealing the end of one rod cutting directly across the main diagonal crack.

The rod had slipped in the concrete near the end of the beam, but adhered firmly to that on the other side of the crack.

It is to be noted that the artificial joint, where diagonal failure was expected to occur, was closer to one point of support than was the crack which actually occurred at the other end. Thus the diagonal stresses were larger on the artificial joint than they were where the mass concrete failed.

The results obtained in this particular beam may be summarized as follows:

(*a*) In a beam, a horizontal joint not reinforced with steel, even if carefully bonded with acid and grout, is such a cause of weakness that the beam should be designed of a height only up to the joint, whenever the load is applied at the level of this joint.

(*b*) In a beam, a joint can be made sloping in the direction of the cracks caused by diagonal tensile stresses, which will be as strong as mass work, if the joint is bonded in accordance with the specifications given above.

(c) In a beam, the concrete in the vicinity of a diagonal joint parallel with the lines of maximum diagonal compressive stresses will fail before a joint made oppositely does, if incipient failure has already occurred in the vicinity of what may be called the compression joint and has not done so near the tension joint.

As a general conclusion, it may then be stated, that if proper bonding methods are adopted, with acid and grout, work may be stopped along 45° planes at any point in a beam, at pleasure, between the ends and the third points. In view of the one other test reported beside the writer's, such planes would better be diagonal compression planes. The writer prefers such joints to vertical ones at the centers of beams, where direct tensile and compressive stresses are larger. Further, it is to be remarked that nothing but ample reinforcement, consisting of stirrups or numerous diagonal rods, can compensate for the detrimental effect of a horizontal joint left along or near the central axis of a beam. The writer prefers numerous stirrups, well connected to the tension rods, and amply anchored in the top concrete.

The Board of Supervisors of the Water Department of Minneapolis, Minn., will hold an examination at 10 a. m., March 15, at the office of the City Engineer, to secure eligibles for the position of Supervisor of Waterworks.

A large hydro electric plant involving the expenditure of $5,000,000 is to be constructed on the St. John River at Grand Falls, New Brunswick. The plant will develop 100,000 HP. in electric current which will be furnished to the various cities throughout New Brunswick and Maine. The work involves, among other features, the construction of a number of shafts in rock excavation 130 ft. deep, a power chamber 30 x 260 ft. and 130 ft. deep, and a tail race tunnel 28 ft. in diameter and 2400 ft. long, a power house 350 ft. long and 260 ft. wide. The intake shafts will be nine in number and 12 ft. in diameter, 130 ft. deep. The work is to be done for the Grant Falls Power Co., the Frank B. Gilbreth organization of New York having the contract. John J. McRae, Ottawa, is the Chief Engineer and Ralph Mershon, New York City, is the electrical engineer.

Earth and Rock Section

Note: This Section is devoted to methods and costs of excavating earth and rock and building embankments. It will cover the grading of roads and railroads, diking and canal work, dredging, building reservoirs and earth dams, sewer and water pipe trenching, quarrying, etc.

Methods and Cost of Constructing the New Raton Tunnel for the Atchison, Topeka & Santa Fe Ry. Co. at Raton Pass, New Mexico.

BY JOS. WEIDEL.*

During the latter seventies of the past century, when the Santa Fe Railway was built westward and southward through Colorado and New Mexico, a tunnel was found to be necessary in crossing the divide of the Raton Range, a spur of mountains projecting eastward from the Taos Range in southern Colorado. This tunnel was built during the years of 1878 and 1879, and while it was under construction a switch back was used in crossing the range. Its length is 2,037 ft. and it is on an ascending grade of 2 per cent from the east, the summit being at the west portal. The grades approaching the tunnel, from either end, are 184.8 ft. per mile. The tunnel is 18½ ft. high above top of rail and has a clear width of 11 ft. About 50 per cent of the tunnel is lined with timbers.

This original tunnel had been in constant use for about 29 years when the increase in traffic, size of rolling stock, and loads, and the necessity of extensive repairs forced the company to build a new tunnel. The new tunnel occupies a site adjacent to the old one and at the east portal the two are only 10 ft. apart, center to center. At the east portal the subgrade of the new tunnel is about 12 ft. lower than the sub grade of the old tunnel. The new tunnel is on an ascending grade of 0.50 per cent from the east; the summit being at the west portal.

The new tunnel is 2,786 ft. long, 17 ft. wide at spring line, and 24 ft. high above top of rail and is lined throughout with a concrete wall of an average thickness of 21 inches. There are two shafts approximately 6x10 ft. in the clear. One of these shafts is 686 ft. from the east portal and the other 1,100 ft. from the west portal.

The contract for the construction of the tunnel was awarded to The Lantry Contracting Co., a Kansas corporation, organized for this particular purpose. The papers were signed on April 5, 1907, and stipulated that the tunnel was to be completed, ready for track laying, by March 1, 1908. There was a penalty and premium clause in the contract of $100 per day for every day's variation from the stipulated time of completion.

In what follows, it must be borne in mind that the contractor had not hitherto been in the business of tunnel building and he consequently found himself without a suitable working plant or organization at the time the contract was signed.

Mr. Charles E. Higbee, of Denver, Colo., was engaged as Superintendent of Tunnel Excavation and Mr. S. A. Maley, of Kansas City, Mo., was engaged as Superintendent of Concrete Work. Both of these gentlemen had had wide experience in their respective fields, and it was under their direction that the work was successfully completed.

A central power plant was installed near the west end of the tunnel. The principal items of this central plant were, one battery of two horizontal tubular boilers of 100 H.P. and 80 H.P., respectively; one Sullivan Straight Line Air Compressor W. B. 2, 20x22-in. cylinder, one 90 H.P. Armington & Sims steam engine for driving the generators; two 25-kilowatt Bipolar Edison Generators of 125 volts; together with pumps, tanks, steam and water pipes and such other appliances as are needed in an up-to-date power house.

A secondary steam plant was located on top of the mountain for the purpose of supplying power for operating the hoists at the shafts. A 100-h.p. boiler was installed and the steam was carried in pipes laid on the surface of the ground, from the boiler to the hoist, for a distance of 500 ft. each way.

From the central power plant at Lynn a 4-in. air line was laid along the surface of the ground, over the top of the mountain, to the Wootton portal. At the Lynn portal, as well as each of the shafts, 2 in. tees were inserted from whence the air was carried down into the headings and shafts by 2 in. pipes.

The drilling machinery consisted of ten Sullivan piston and ten Jeffrey rotary power drills. For ventilating, two No. 1½ Baker's rotary blowers were secured. These were operated by two 7½ h.p. motors of 230 volts and 28½ amperes. This outfit was moved from place to place as needed. The cages in the shafts were operated by hoisting engines, using either compressed air or steam.

For excavating the bench, a No. 20 Marion steam shovel was used. This shovel was operated by compressed air from the central power plant. Three dinky engines kept the shovel supplied with cars. Ten 3 cu. yd. dump cars were needed to supply the shovel, five in a train.

The rock crushing and concrete mixing plant consisted of one Ajax [illegible] engine mounted on wheels, one Simmons No. 10 rock crusher, one ⅝ cu. yd. concrete mixer of the Ransome type, ten 1½ cu. yd. dump cars and an incline for hoisting the loaded cars from the tunnel grade onto the working platform at the spring line.

There was also constructed an electric light and power line over the mountain for supplying light and power to the camps and tunnel. A telephone system was also installed.

The grading outfit was of the usual kind.

Owing to the lack of water on top of the mountain the company shipped in four tank cars full every 24 hours, approximately 10,000 gals. being required for all purposes each day.

On April 25, 1907, ground was broken for the power plant at Lynn. While the camp and power plant were in course of construction work on excavating the approaches at Wootton and Lynn was in progress. On April 3 work was begun excavating the shafts. The drilling was done by hand and the excavated material was hoisted by animal power. These shafts were dug about 8x12 ft. in the clear and were 109 and 115 ft. deep, respectively, measured from the crown of arch in tunnel. The material penetrated was soft sandstone, hard shale and some coal.

By May 9, when the power plant was ready for service, the excavation of the shafts had been practically completed, all of the work having been done by hand and animal power. For the benefit of those who may have occasion to construct shafts under similar conditions, I submit the following table, which shows the cost of excavating Shaft No. 1:

Foreman at $1.50	$ 375.25
Shaft men at $3	1,792.50
Nippers at $2	32.00
Timber men at $3.50	56.00
Teams at $2.50	132.50
Teamsters at $2	96.00
327 cu. yds. excavation at	$2,481.25

The cost per cubic yard of excavation was, then, as follows:

	Per Cu. Yd.
Labor	$7.60
Explosives	.75
Supervision	.65
Total	$9.00

It may be stated that this includes the placing of approximately 20,000 ft. B. M. of timber lining.

On May 9 the actual work of tunnel excavation was begun by shooting the first round of holes in Heading No. 6 at the Lynn portal. On May 21 heading No. [illegible] was started and on May 28 heading No. 1 was started. On July 9 headings No. 5 and No. 6 met at Station 7+12, Lynn end, and on same date headings Nos. 2, 3 and 4 were started. Headings Nos. 1 and 2 met on Aug. 8 at Station 8+10, Wootton end. Headings Nos. 3 and 4 met on Sept. 8, 1

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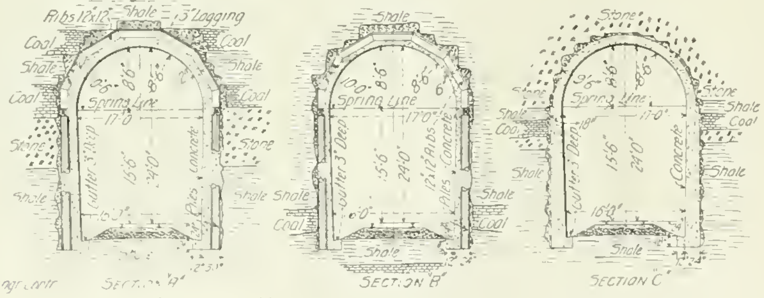
*Assistant Engineer A. T. & S. F. Ry., Topeka, Kan.

Station 2+00, Wootten end, thus completing a hole through the mountain 2,786 ft. long in 122 days from time of beginning.

In taking out the headings it was found that from 12 to 18 holes were necessary to cover the face in a satisfactory manner. The center set of holes was pointed so as to remove a wedge of rock; other holes were then pointed straight ahead. Those at the sides, top and bottom were pointed slightly outward. The average depth of these holes was 8 ft. and the diameter 2½ ins. Sullivan piston and Jeffrey rotary drills, the former mounted on tripods and columns and the latter on the usual frames, both operated by compressed air at 90 lbs. pressure, were used.

As soon as the drilling was finished the holes were cleaned by blowing compressed air into them. They were then charged with dynamite, which was exploded by fuse. Fuses instead of electric exploders were used because the former permit of timing each shot in such a way as to give the best results from the explosives used. For instance, the central set of holes is fired first, removing a wedge so that the succeeding shots will have two free faces toward which they can break the rock. The "muckers" at the bottom are fired last. Their function is to throw back the debris so that the drillers will be delayed as little as possible before they can proceed with the next set of holes.



Sections of Raton Tunnel, Atchison, Topeka & Santa Fe Ry.

The shots were generally fired just before meal time. Immediately after they had been fired, compressed air was permitted to escape into the headings and the ventilating fans were started. It was thus possible to clear the headings of gases so that they could be entered after the meal hour without loss of time. Before firing the shots, sheets of boiler iron were spread on the ground just in front of the holes to facilitate the handling of debris after blasting.

When the workmen returned from their meals the headings had usually been cleared of gases and fumes and the drillers and their helpers would enter and proceed to shovel back any rock that was found to obstruct the working front. As soon as this was done, they proceeded to drill a new set of holes for the next blast. The debris was loaded by from six to ten laborers onto cars of 1½ cu. yds. and 2/3 cu. yd. capacity. The former were used in the headings No. 1 and No. 6, while the latter were used in headings Nos. 2, 3, 4 and 5. The former were pulled by animal power to the portals and the latter were propelled by man power to the shafts. From the portals the 1½ cu. yd. cars ran by gravity to the waste bank, the empties being brought back by horses or mules. The smaller cars at the shafts were raised to the surface by hoisting engines operating cages.

The following is a statement of the cost of excavating heading No. 6:

	Rate.	Total.
Machine foremen	$4.50	$ 495.00
Machine men	4.00	1,196.00
Machine helpers	3.50	1,046.00
Nippers	2.50	507.50
Muck foremen	3.50	387.00
Laborers	2.25	2,975.50
Teams	2.50	315.00
2,897 cu. yds. material excavated		$6,922.00

The cost per cubic yard for excavation was as follows:

	Per Cu. Yd.
Field labor	$2.39
Labor operating power plant	0.31
Labor in camp and supervision	0.88
Powder, fuse and caps	0.55
Coal	0.30
Depreciation	0.65
Total	$0.08

A summary of the total and unit costs of all six headings is given below:

No.	Length. Ft.	Cu. Yds.	Total Cost.	Cost Per Cu. Yd.
1	476	3,165	$17,534.10	$5.54
2	210	1,026	5,550.56	5.41
3	400	1,845	8,320.95	4.51
4	600	2,334	13,233.78	5.67
5	312	1,564	9,271.52	5.93
6	788	2,897	14,716.76	5.08

The material penetrated in heading No. 1 was soft sand stone, while the other headings were mixed sand stone, coal and shale. The most rapid progress was made in heading No. 6, where there was no timber lining to contend with. The average daily progress in this heading was 12½ ft., while for the last nine days the daily average was 17 ft. This, of course, means per 24 hours. About 55 per cent of the headings were taken out through the shafts.

In moving the bench, holes were drilled vertically about 7 ft. apart. These were shot as in open cut work. The muck was loaded by a No. 20 Marion steam shovel, operated by compressed air. Ten 3 cu. yd. dump cars were used, five in a train. These trains were operated by three dinky engines, one switching at the shovel, one taking the excavated material to the waste dump and one in reserve.

Following is the steam shovel monthly progress:

July	50 ft.	October	355 ft.
August	420 ft.	November	565 ft.
September	510 ft.	December	500 ft.

About 88 per cent of the bench was removed by steam shovel and 12 per cent by hand. If we take into account the entire tunnel excavation, 25 per cent came out through the shafts and 75 per cent through the portals.

The steam shovel began work on July 29 and finished on Dec. 23, a period of 148 days. Below follows a table showing the cost of removing 29,417 cu. yds. of bench excavation by steam shovel:

	Rate.	Total.
Foremen	$4.50	$ 1,300.50
Steam shovel engineer	6.50	1,839.50
Crane men	3.50	897.00
Dinky engineers	3.50	1,791.00
Machine men	4.00	3,604.00
Machine helpers	3.50	3,244.50
Pit men	3.00	5,793.00
Laborers	2.00	6,151.75
29,417 cu. yds		$24,621.25

The cost per cubic yard was as follows:

	Per Cu. Yd.
Field labor	$0.88
Labor operating power plant	0.09
Camp labor and supervision	0.26
Powder, fuse and caps	0.17
Coal	0.09
Depreciation	0.19
Total	$1.68

In excavating the tunnel no unusual difficulties were encountered. There was very little water to contend with and the material penetrated was sand stone, shale and coal. About two-thirds of the entire tunnel had to be temporarily lined with timbers. The work was done in the following manner:

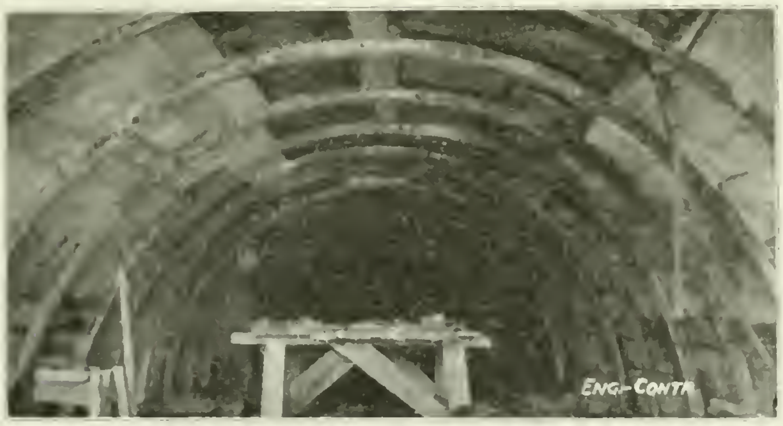
As soon as the headings had advanced sufficiently a gang of drillers was set to work enlarging the section to the full semicircle required. Sills consisting of 12x12-in. timbers were bedded at the spring line on each side of tunnel, so that the outer face was a uniform distance of 6 or 12 ins. from the face of the concrete. Engineers gave grade and centers for these and in placing them they were set 4 ins. higher than the theoretical requirements. This was done to allow for subsequent settlement during the excavation of the bench. As soon as the sills were bedded to proper grade, the segments, six in number, were placed. These were made of 10x12-in. pieces, or an equivalent section of 3x12-in. or 4x12-in., was built up. The sill, by the way, was also built up of 3x12 or 4x12-in pieces, set edgewise. The segments were spaced 3 ft. on centers. Over the segments 3-in. lagging was placed, this having previously been cut into 4 ft lengths by means of a circular saw. As soon as the lagging was placed, the void spaces between the lagging and the roof of the excavation were packed solid with stones of various sizes. As fast as the bench was excavated by the steam shovel, it was of course necessary to support the sills at spring line. In this case ordinary piles about 12 ins. in diameter were used. These were spaced variously from 3 to 6 ft. apart, according to the load to be supported. Where the loads were light it was found that short stulls from 4 to 6 ft. long made of 8x8 in. stuff answered very well for supporting the roof timbering. In such cases, horizontal struts had to be inserted to prevent the timbers from kicking in at spring line.

The work of enlarging the section, the placing of timbers and the back filling was done by the same set of men. Owing to this circumstance the records of cost data are somewhat less satisfactory in this case than in other portions of the work. Of these three items the records for the cost of enlarging the tunnel section are quite reliable. By subtracting this cost from the total cost of performing the different classes of work, we have an amount which represents the cost of labor placing the timbers and the cost of labor placing the back filling.

The cost of enlarging the tunnel section was $2.55 per cu. yd. After repeated trials the cost of placing the timbers was ascertained to be $15.55 per M. ft. B. M. By subtracting these two, the cost of enlarging the section and the placing of the timbers, the remainder was assumed to represent the cost of back filling. By this process of reasoning it was found that the cost of placing the back filling was $1.50 per cu. yd. In the abstract such reasoning may be correct, but practically the writer has little faith in the results. Summing up, then, it may be assumed that the cost of enlarging the section is correctly represented by $2.55 per cu. yd., that the cost of placing the timbers lies between $12 and $18 per M. ft. B. M. and that the cost of placing the back filling was not ascertained.

While the steam shovel was taking out the bench a gang of men was excavating for the footing course of the concrete walls. As soon as portions of these trenches were excavated another gang placed the concrete in the foundation. The mixing was done by hand on sheets of boiler iron placed in front of the trenches. These were moved from place to place as required. However, before any concrete was placed, carpenters erected a sufficient amount of forms to define the neat line of concrete at grade. For setting these forms engineers gave the grade and center points and after the concrete was once placed to this line no further instrumental work was required. All of the foundation concrete up to the grade line of the tunnel, was placed in the manner indicated above.

For the real work of lining the tunnel the contractor installed a rock crushing and concrete mixing plant in the approach at Lynn, about 200 ft. from the portal. The rock was quarried from the adjacent hill, within 100 ft. of the crusher, which was a No. 10 Simmons. The mixer was of the Ransome type, mixing 5/8 cu. yd. per charge. The crusher was at the top of the approach slope, about 20 ft. above grade. A bin, divided into three compartments, was placed above and to one side of the track in the approach. In the bottom of the compartments were chutes discharging into a measuring hopper. Immediately below the hopper was the mixer and below the mixer and a little to one side stood the cars that received the mixed concrete. The rock was carried from the crusher into the bin by a small chain elevator and the sand was handled in a similar manner. The cement was carried to the bin in sacks. Water was supplied by a 2-in. pipe discharging into the mixer, the amount being controlled by a boy operating a valve. One man operated the measuring apparatus and one attended the mixer.

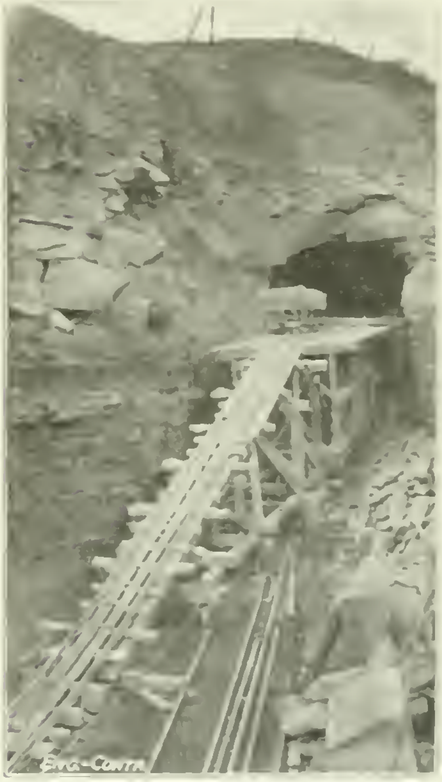


View Showing Steel Rib Rail Centers for Raton Tunnel.

It will be seen that the entire process of handling the material from the crusher until the concrete reached the cars was mechanical and from the bin to the cars gravity did the work.

The crusher was operated by a stationary engine and the mixer and elevators by independent electric motors. The cars were handled by dinky engines. The sand was shipped from La Junta. The crushing and mixing plant was a complete success from every point of view.

Originally it was the contractor's intention to place all of the concrete lining above foundation line off a movable platform at spring line. With this idea in view a standard flat car was secured from the railway company and by means of frame work placed upon this car a platform 17 ft. wide and 50 ft. long was supported at the elevation of spring line. The car was carried on a track laid in the center of the tunnel. In order to elevate the concrete cars as they arrived from the mixing plant to spring line, an inclined plane with a narrow gage track and mounted on wheels was coupled onto the platform mentioned above. On the flat car was mounted a hoisting engine operated by compressed air. The cars were pushed to the bottom of the incline by dinky engines, where a cable was hooked onto them and they were then hoisted to the top of platform by means of the hoisting engine. Once on top, the concrete was dumped onto the platform and cars returned by gravity to tunnel grade. The concrete was then shoveled into the forms and the idea was that the arch ring would also be turned at once before advancing the incline and platform to a new position. It was found to be impossible to turn the ring fast enough without delaying the placing of concrete in bench walls. A feature of the forms was to use two 10 lb. bent rails, one on each side and meeting at soffit line, as ribs for supporting lagging



View Showing Incline Platform Used in Concreting Arch Ring.

for concrete. It is evident that a movable platform will not permit of bracing these ribs crosswise of the tunnel axis. Owing to this circumstance these ribs lacked stiffness and bulged out considerably when concrete was shoveled into the forms. The long and heavy bent rails were also very difficult to handle. Owing to these drawbacks, this method of placing the concrete was abandoned.

During the short time that the above method of placing the concrete was in vogue it became evident that, in order that work might be carried on without interruption, a platform of considerable length was necessary. It was decided, therefore, to erect a fixed platform at spring line 17 ft. wide and 500 ft. long. Instead of the bent rails for ribs, 6x8-in. vertical studding spaced 4 ft. on centers was used. These pieces extended from grade line to spring line and were cross braced about 10 ft. above grade line. On top of these uprights were placed 6x10-in. caps, which acted as beams for carrying the loose 2-in. platform floor. The lagging was placed directly behind the vertical studs, to which it was loosely nailed. The old movable platform, mounted on a flat car, and the inclined plane, were then run up to the 500 ft. fixed platform and the concrete was hoisted as before.

While the carpenters were placing the fixed platform, the mixed concrete was brought in and dumped onto sheets of boiler iron at grade line and from there was shoveled into the forms to a height of about 6 ft. above grade. By the time that this height was reached the platform was ready and all concrete above this 6 ft. line was then placed from the fixed platform at spring line. In the center of this platform, for its full length, was a track connecting with the track on the incline. The cars, after they had been hoisted to the platform, were pushed by men to different places and dumped. The cars were then pushed back to the incline and lowered to tunnel grade by gravity, controlled by hoisting engine on movable platform. The concrete was shoveled into the forms until the spring line was reached. As soon as a portion of the bench walls had reached spring line a gang of men erected rail ribs of a 40-lb. section bent into the form of a semi-circle to receive the lagging for turning the arch ring. These rails were generally made in two pieces and were spaced 4 ft. on centers. The lagging was 2-in. stuff and was placed as fast as the placing of concrete required it. The distance from spring line to soffit line is 8½ ft. The placing of concrete in the arch ring for the first 6 ft., did not differ materially from the method of placing it in bench walls, only a little more tamping was necessary to fill the voids. After a point was reached where it was too high to cast in the concrete from the platform at spring line, a small movable platform on wheels, about 8x10 ft. and 4 ft. high, was pushed under the arch and the concrete was shoveled from platform at spring line onto this smaller platform and from there into arch ring until only a 3 ft. gap remained to be closed.

This was an awkward job and required the closest attention on the part of the foreman to prevent the men from slighting their work. The concrete had to be shoveled in endwise and to facilitate this the length of the lagging for the last 3 ft. of arch ring was cut down to 3-ft. lengths. The concrete for this was made dryer to prevent it from sloughing back when the tamper was withdrawn.

The temporary timber lining was imbedded in the concrete and had been so placed that at least 6 ins. of concrete was in front of all ribs and sills. In places where the timber had settled or swung out of line, the timbers had settled to such an extent as to weaken the arch, the wooden ribs were replaced by bent rails.

The progress made in lining the tunnel by months was as follows:

	Cu. Yds.
October	326
November	1,000
December	985
January	1,986
February	4,173
March	2,931
April	1,025

Besides the tunnel lining proper, the two shafts were also lined with concrete. This was done by force account. At the Wootton end a reinforced concrete portal wall was built and at the Lynn end one of plain concrete was constructed.

The cost per cubic yard of placing concrete, exclusive of the cost of cement, was found from records kept by the assistant engineer to be as follows:

	Per Cu. Yd.
Forms and platforms, labor	$0.63
Forms and platforms, lumber	0.54
Crushing and quarrying rock	0.89
Cost of sand (no freight)	0.18
Cost of handling sand at tunnel	0.18
Cost of handling cement at tunnel	0.17
Cost of housing cement at tunnel	0.04
Mixing and transporting concrete	0.41
Placing concrete into forms	0.81
Removing forms and pointing	0.32
Supervision and camp labor	0.66
Labor operating power house	0.20
Coal	0.34
Depreciation of plant	0.65
Nails, oil and candles	0.03
Rental on rails and ties	0.03
Total	$6.08

The lining of the tunnel proper was completed on April 15, while the whole contract was finally completed on June 20, 1908, 441 days after ground was broken.

The cost of the contractor's plant in this case was estimated at $55,000. The outfit was purchased especially for this contract and at the conclusion of the work the contractor offered to sell the plant at 50 cts. on the dollar. This fact accounts for the heavy depreciation charge in the unit costs.

The unit costs given in this article are based upon records kept by the writer as assistant engineer in charge for the railway company. A man was employed to keep this record, who had no other duties to perform, and the results were tabulated every day. From facts known to the writer it is his belief that 10 per cent should be added to these figures to arrive at the actual total cost.

The work was planned and carried on under the direction of Chief Engineer C. A. Morse, of Topeka, Kan., and Engineer F. M. Bisbee of La Junta, Colo. The field force consisted of Assistant Engineer Jos. Weidel with an instrument party and, latterly, during the construction of concrete work, one day and one night inspector.

Method and Cost of Trimming the Side of a Rock Excavation.

In open cut work where rock is encountered the rock sides of the cut seldom have to be dressed up with any nicety, but in foundation work it is often necessary to do so and also in canal construction. Where large areas of the sides of cuts are to be smooth and even, channeling machines are used, but on small jobs the work is generally done by hand. In New York city this character of hand work is often done on cellar excavation, to admit of machinery being installed and structural steel and brick walls being erected.

The following example was on such a piece of work in New York, the work being mica schist. After the excavation was made, one side for a distance of 64 ft. had to be dressed up. From about 2 ins. to 5 ins. of the rock face had to be clipped off. The work was done by men working two together, one holding a heavy bull point, by an iron handle, and the other using a striking hammer. For 4 days 4 men were engaged on the job, and for 3 days 6 men were at work. With wages $1.50 per day of ten hours, this gave a cost of $51. Ordinary laborers were used to do the work. For 32 ft. the rock cutting was 8 ft. high and for the other 32 ft. it was only 6 ft. high, making in all 448 sq. ft. This gave a cost of 11.4 cts. per sq. ft. of rock face trimmed. Two men working together did on an average of 26½ sq. ft. per day. These costs do not include any allowance for dressing the bull points.

The Board of Water Supply of New York City is calling for bids for two large contracts in connection with the construction of the Catskill Aqueduct. One of these contracts calls for the construction of a deep pressure tunnel in rock 14½ ft. in inside diameter and about 23,400 ft. long The bids are to be opened March 18 and 22.

The U. S. Senate on Feb. 27 passed the River and Harbor bill carrying appropriations aggregating $9,700,000.

Roads and Streets Section

Note: This Section is devoted to methods and costs of road and street construction. It will cover road building in all its details, the construction of pavements, sidewalks and gutters, the testing and use of paving materials and the machinery and tools used in road building and paving.

Amount and Cost of Repairs to Asphalt Pavements at Syracuse, N. Y., and Proper Method of Determining Time for Ceasing Repairs and Renewing.

Valuable data on the amount and cost of repairs of asphalt pavements at Syracuse, N. Y., are given in his annual report by City Engineer H. C. Allen. In addition to the data on life and cost, the report presents a plan, which will interest city engineers, for determining when repairs should cease and the pavement be resurfaced. We quote Mr. Allen's report as follows:

The first asphalt pavements in Syracuse, N. Y., were laid in 1889, 20 years ago. Since that time more or less of this kind of pavement has been laid each year, excepting 1891 and 1892, until at present there are about 625,000 sq. yds., outside of the railroad strip and exclusive of asphaltina. In 1902 the Department of Public Works commenced to systematically repair all asphalt pavements out of guarantee and to make a record of the amount of work done and its cost.

Following is a table showing the total number of square yards of asphalt pavement out of guarantee, and the total cost of repairs each year from 1902 to 1908, both inclusive:

Year	Total Sq. Yds.	Repairs Sq. Yds.	Cost
1902	154,498	1,414	$ 2,676.40
1903	241,125	2,710	4,586.15
1904	381,180	5,617	9,628.37
1905	396,814	9,308	13,275.13
1906	450,427	14,958	19,117.43
1907	457,152	17,574	24,092.21
1908	494,394	17,521	24,028.03
Totals		69,102	$97,711.36

The total amount of asphalt pavement required was 69,102 sq. yds., and the cost $97,711.36. Besides this, there has been a large amount of asphaltina pavement repaired. The laying of asphaltina ceased in 1890 and it has always been kept in repair with asphalt.

During the past two or three years it has been observed that the older asphalt pavements, those laid in 1895 and previous thereto, were fast reaching a condition impracticable to repair, and a time when a new surface must be laid. It was also noticeable that the greater part of the cost of repairs was upon these old pavements. Because of these observed facts, and the constantly increasing annual charge for repairs, a study and analysis of the records were undertaken with a view to recommending a policy on the part of the Department of Public Works with reference to the maintenance of this class of pavements. According to the provisions of the Charter, the cost of paving streets has been paid by the owners of abutting property and after the expiration of the guaranty period, the Department of Public Works has made the necessary repairs. The analysis above referred to show that the cost per square yard per year for repairs to asphalt increases in an increasing ratio. This ratio has been estimated from experience with the pavements in this city as follows:

Year of the Pavement Life.	Cost Per Sq. Yd. Per Yr at $1.41 Per Sq. Yd.	Total Cost to Date Each Yr Sq. Yd.
6th	$0.003	$0.003
7th	.011	.014
8th	.014	.028
9th	.028	.056
10th	.035	.091
11th	.056	.147
12th	.085	.232
13th	.127	.359
14th	.169	.528

It is apparent from these figures as well as from the contemplation of the increasing actual cost from year to year, that the repairs to asphalt pavements by the Department of Public Works can not go on indefinitely without involving the resurfacing of entire pavements.

The Charter provides that the resurfacing of street pavements shall be done at the expense of the owners of abutting property, and the problem here to be solved is the determination of the time at which the Department of Public Works shall cease making repairs, and leave the pavement to be resurfaced in the manner provided by law. Several suggestions have been made: one that a pavement having once been laid the City shall keep it in repair for a certain period of years, say, until it is 15 years old; another that a pavement shall be kept in repair by the City until a certain percentage of its area shall have been repaired.

Objection is found to the first proposition in that the lives of pavements vary with their location and the volume of traffic to which they are subjected. Some of the asphalt pavements are found to have had as low as 1 per cent. of the total surface repaired and to be still in fair condition at the end of 12 years, while others not so favorably located and sustaining heavy traffic have had more than 50 per cent of the total surface repaired in the same period and are not capable of further repairs. It is evident that a hard and fast rule that all asphalt pavements must be resurfaced at the end of 15 years of life will not operate in an equitable and consistent manner, for the reason that in some cases the condition of the pavement, due principally to its use, will require resurfacing at an earlier period and in others the rule will require the destruction and replacement of a pavement which still has in it the ability to render service for a longer period.

The proposition that the City keep an asphalt pavement in repair until such a time as a certain percentage of its total area has been repaired seems to meet the requirements of the situation in a more practical and equitable manner.

The study of the information contained in the record of repairs shows that after the tenth year of life, the amount of repairs per square yard per year increases at a much more rapid rate than in previous years. The results obtained by taking the mean or average of the quantity of repairs to pavements which have reached the age considered is as follows:

Year.	Amount of Repairs	Sq. Yds.
11th Year	Per Sq. Yd., Per Year	.04
12th Year	Per Sq. Yd., Per Year	.06
13th Year	Per Sq. Yd., Per Year	.09
14th Year	Per Sq. Yd., Per Year	.12
	Total repairs	0.31
	Average from 6th to 10th year inclusive	0.065
	Total for 14 years	0.375

It is also to be observed that in the majority of pavements the general condition at the time repairs to the extent of 37½ per cent have been made is such as to render further repairs impracticable, and resurfacing necessary.

Taking the average of all pavements of this kind, it is found that at the end of the 14 years of life the percentage of 37½ per cent of the total area has been repaired, the extremes being such streets as North and South Salina, which reach the limit in 11 years, and others such as Davis and Fitch streets which have not required 5 per cent repairs in 12 or 13 years.

It is therefore recommended that it be the policy of the Department of Public Works to keep up the repairs to asphalt pavements until such time as the total repairs thereon have reached 37½ per cent of the total area; that having made repairs to that extent upon any pavement it be abandoned for further repairs, and reported to the Common Council as a proper object for resurfacing. It should be noted in connection with this discussion and the general one of the participation by the City at large in the cost of pavements, that by paying the cost of repairs until the time the percentage of total surface above commended has been reached, the City at large participates in the cost of the pavement during the period of its life to the extent of about 53 cts. per square yard or about 30 per cent of the total cost of the perishable portion of the pavement.

If it is thought to be advisable that the general scheme of paving assessments now in force should be changed by Charter amendment, so that the City at large is made to participate in a portion of the original cost of a pavement, it is suggested that it would be an equitable arrangement in making such assessments to consider that the streets crossed by any proposed pavement are City property fronting the improvement, and to charge the cost of the pavement to this property at the same rate per foot front as other property along the line is called upon to pay. The application of this rule during 1909 would result as follows:

REPAIR TO ALL PAVEMENTS LAID SINCE 1895—ESTIMATED COST.

Laid.	Age.	Sq. yds.	Estimated cost of repairs per sq. yd. per year.	Amounts.
1896	13	25,428	$0.127	$3,229.36
1897	12	20,733	.085	1,762.31
1898	11	106,609	.056	5,970.10
1899	10	109,927	.035	3,847.45
1900	9	9,409	.028	263.45
1901	8	53,613	.014	750.58
1902	7	6,725	.011	73.97
1903	6	17,257	.003	51.77
				$15,948.99

Add all pavements laid previous to 1896 which 37½ per cent of the area has not yet been repaired.

Laid.	Age.	Sq. yds.	Estimated cost of repairs per sq. yd. per year.	Amounts.
1895	14	7,172	$0.169	$1,207.00
....	15	10,857	.212	2,301.68
....	19	22,538	.013	*292.99
....	20	629	.25	157.25
				$3,958.92

*Resurfaced 1902-3.

SUMMARY.

	$15,948.99
	3,958.92
	$19,907.91
Contingencies 10% =	1,990.79
	$21,898.70
Say =	$22,000.00

This contemplates the abandoment for repairs of the following:

Amt. of repairs to date.	Age.	Location.	Sq. yds.
.502	14	N. Salina St., Butternut St. to Oswego Canal, First Ward (ordered resurfaced 1908)	20,634
.530	14	N. State St., James St. to Erie Canal	2,494
.496	15	N. Clinton St., W. Genesee St. to Erie Canal	229
.435	15	Montgomery St., E. Genesee St. to E. Jefferson St	2,119
.522	15	E. Onondaga St., S. Salina St. to S. State St	6,842
.679	15	S. Salina St., Castle St. to Brighton Ave. (ordered resurfaced in 1908)	12,825
.435	15	S. Warren St., Onondaga to Salina Sts.	5,905
			51,048

The U. S. Civil Service Commission, Washington, D. C., will hold an examination on March 10-11 to secure eligibles from which to make certification to fill vacancies as they may occur in the position of Civil Engineer in the Philippine Service. The entrance salary is usually $1,400 a year. There are, however, similar positions in that service paying higher salaries, and it is desired to secure from this examination eligibles who are qualified to fill the higher-salaried positions in the event that vacancies therein occur. Appointees are allowed field expenses when absent on duty from their permanent station. It is especially desired to secure eligibles who have had experience in river or harbor work, to fill two positions, one at $1,800 and the other at $2,000.

The total amount of material excavated by dredges in January in the construction of the Isthmian Canal was 1,108,677 cu. yds., of which all but 14,772 cu. yds. was taken from the Canal prism.

Economic Hints for Macadam Road Contractors.

The following hints are not all applicable to any one job nor to any one locality, but embrace much of the contracting experience of the writer in building roads in several different states. Even though an experienced contractor may himself know how to do work economically, it is often difficult for him to get his foreman to do the work as he himself would do it. Hence the advisability of having a printed set of hints or instructions for foremen, to which additions can be made from time to time, after the method so well carried out by Mr. Frank B. Gilbreth in his book, "Field System."

Each road contractor will have experience of his own which can be condensed into concise hints that will lead to more economic road construction on the part of his foremen. To such contractors the writer offers the following series of hints as a nucleus about which they may group others.

1. If possible, secure a written option on a quarry before you put in your bid on a road, if you plan to do your own quarrying.

2. In bargaining for the quarry avoid signing any agreement to pay a quarry royalty by the cubic yard or wagon load, for such agreements often lead to litigation.

3. Purchase a quarry site outright, if you can buy the land by the acre at farm land prices. If this cannot be done, endeavor to pay for the stone in a lump sum, say $100 "for the right to quarry enough stone to build a macadam road —— ft. wide, —— ins. thick after rolling, and —— miles long."

4. Select a quarry site where the earth stripping is the least, provided other things are equal. Following this suggestion will frequently lead to selecting a quarry site in the bed of a creek or river that runs nearly dry in summer. Small streams can be diverted to one side of the bed by building a small earth dike, leaving the rock exposed.

5. A quarry on a hillside is preferable to one on level ground, for it requires no pumping to keep it dry, and it requires no steep pull to haul the stone away.

6. Beware of granite and gneiss quarries, as a rule, for the stone is apt to require not only very close spacing of drill holes, but a great amount of sledging to bring it to a size that will enter the ordinary portable crusher. It is not unusual to have the cost of quarrying and crushing granitic rock run up to $1.50 per cu. yd. of loose stone, or more.

7. In buying a quarry, bear in mind that every additional mile of haul from the quarry to the road will cost you 26 cts. per cu. yd. of broken stone, where wages of team and driver are 50 cts. an hour and where the average wagon load is 1½ cu. yds.

8. In figuring how many cubic yards of broken stone will be obtained from one cubic yard of solid stone, figure 1.7 to 1¾ cu. yds. of broken stone from 1 cu. yd. of solid stone. Hence, if you must pay quarry rental by the cubic yard, endeavor to buy it by the cubic yard of solid stone in the quarry, and engage an engineer to cross-section the quarry before and after.

9. If you plan to quarry any stone during the winter, strip all the earth off before freezing weather sets in.

10. Quarrying in winter is expensive, for the men cannot work as well. Moreover, you will have the additional expense of building stock piles of broken stone and of subsequently rehandling it in loading wagons. It pays better to buy another crusher and rush your work in the summer.

11. Never attempt to quarry and crush your stone in the winter and stack it up in piles along the road side. Hauling in winter is expensive. The piles of stone along the road will be in the way of the grading gang. It will cost fully 15 cts. per cubic yard to shovel the piles of stone into the road.

12. Ordinarily it is preferable to use a jaw crusher for a portable plant and nearly all road making plants must be portable in a country where rock is plentiful. Use a gyratory crusher for large stationary plants, supplementary by a jaw crusher or a small gyratory for crushing the large tailings rejected by the screen.

13. Crushers are generally guaranteed to have a certain minimum capacity of broken stone per hour. Written guarantees of this sort should specify a run of not less than 5 hours, for a crusher can be run at excessively high speed for a short time—so high a speed that the bearings would become so hot as to set fire to the oil if kept running much longer at that speed. The guarantee should also specify the size of the stone that is to be fed into the crusher. Obviously very small chunks can be run through much faster than those of ordinary size.

14. If the quarry is a pit, put the crusher up out of the pit, so that the wagons hauling stone from it will travel on level roads. Otherwise a snatch team will be needed to get large wagon loads of broken stone out of the pit.

15. Ordinarily the cheapest way to deliver the stone to a crusher from the quarry face is in small one-horse dump carts. One driver can handle two or more of these carts, for, while one cart is being loaded, the driver leads the other horse and cart to the crusher. Such a cart can be hauled up quite a steep grade and its contents dumped from a platform into an inclined chute feeding into the crusher.

16. Dump the stone into a chute, as just described, in preference to dumping it onto a level platform, for one man can then feed a crusher almost as fast as two otherwise.

17. Traction engines for hauling crushed stone are frequently not used, simply be-

cause the contractor has made the mistake of setting up his crusher in the quarry pit where there is not room to turn a traction engine and a train of wagons around.

18. The ordinary size of portable jaw crusher has an opening about 9 x 16 ins., and is very commonly run with 12 H.P. engine and boiler, but it is much better practice to have an 18 or 20 H.P. boiler, for then there is always an abundance of steam at good pressure.

19. If much crushing is to be done, mount the engine that drives the crusher on a good concrete foundation. There will be fewer delays and fewer boiler troubles if this is done than where the engine is mounted on wheels with the boiler. A rock crusher has very irregular work to perform. One moment it is working to capacity, the next it may be empty and cause the engine to start to race. This irregularity shakes an engine on wheels badly and loosens the boiler tubes.

20. The bucket elevator that lifts the broken stone to the rotary screen is driven by a sprocket chain. If this chain breaks frequently, it is usually because it is stretched too taut. Put in a few extra links so it will be quite loose, and the breaking will stop.

21. Never use anything but a rotary screen to screen the stone. To some it looks like economy in plant to have a fixed screen of parallel bars, and to let the stone fall either into a wagon or on to the ground. This is never economical, even where the specifications permit this sort of screening, for teams will not always arrive exactly on time, and then the crusher must stop or the stone must pile up on the ground to be afterward shoveled by hand. It is not common to see such wasteful methods as this on contract work, but it is frequently seen on country road work done by county forces.

22. Always provide bins for the broken stone, either portable bins on wheels or larger stationary bins which may be unbolted and moved in pieces from one job to the next. It is desirable to have a bin large enough to hold 2 or 3 hours' run of the crusher. If the bin holds 15 cu. yds., divide it into three stalls, the first stall to hold 2½ cu. yds. of screenings (dust to ½ inch size), the second stall to hold 3½ cu. yds. (½ to 1¼ inch size); and the third stall to hold 9 cu. yds. (1¼ to 2½ inch size).

23. The commonest mistake of foremen in building a bin is not to give the bottom a steep enough pitch. In fact, the same mistake is made by many manufacturers who sell portable bins on wheels. A bin with a bottom that has a slope of only 1½ horizontal to 1 vertical will hold more stone than one with a steeper bottom, but the stone will not run out of the chute without the aid of an extra man to push it out. The bottom of a bin should have a slope of not less than 1 to 1, and should be lined with sheet iron, not only to protect from wear but to make the stone slide easily. If a bin has bottom with or slope of much less than 1 to 1, it will take the driver and an extra man fully 6 minutes to load 1½ cu. yds. into the wagon. Whereas, from a bin with a bottom slope of 1 to 1, the same wagon can be filled in 1½ minutes.

A 15 cu. yd. bin that is bolted together, can be taken down, moved a few miles and erected again for about $75. But this usually is not the only cost involved in changing quarries. There is the cost of stripping a new quarry site, of piping for water, of lost time of steam roller, teams, etc., while moving. Still, comparatively frequent moves are often justified to reduce hauling costs. In a macadam road 6 ins. thick (after rolling) and 16 ft. wide, there are 1,564 cu. yds. of solid macadam per mile. It takes 1.6 cu. yds. of loose broken stone and screenings to make 1 cu. yd. of solid macadam. Hence there are 2,500 cu. yds. of loose broken stone and screenings per mile of such a macadam road. Only 3 cts. per cu. yd. saved in hauling enough stone to build a mile of macadam amounts to the $75 cost of moving the crushing plant.

24. A cubic yard of loose broken stone, measured in the wagon at the bin, weighs about 2,400 lbs. (or 1.2 short tons) if it is limestone, sandstone, or granite; but a cubic yard of trap rock weighs 2,700 lbs. (or 1.35 short tons). After traveling a short distance, the stone becomes shaken down and compacted, so that it measures about 10 per cent less in bulk. Hence 1 cu. yd. of broken stone in the wagon at the bin will measure only 0.9 cu. yd. in the same wagon at the point of delivery on the road. Bear this in mind, and make all measurements at the bin. If you are calculating upon covering a certain amount of road to a given thickness with loose stone with each wagon load, you will put on too much stone if you measure the wagon load as delivered at the road.

(To be continued.)

The production of primary spelter from domestic and foreign ores in 1908 in the United States is estimated at 208,000 short tons, worth at the average price $19,656,000, as compared to 249,860 tons in 1907, 221,770 tons in 1906, and 203,849 tons in 1905.

In January the steam shovels at work on Isthmian Canal excavation removed 1,815,784 cu. yds. of material, all but 110,147 cu. yds. of which was taken from the Culebra division. The high record for the month was made by shovel No. 210 (90-ton shovel), at work in the Empire district, which took out 44,225 cu. yds., all but 61 cu. yds. of which was rock, in 25 working days, an average of 1,769 cu. yds. per day. The best record for shovels in the 70-ton class was made by shovel No. [illegible], working in the lock site at Gatun, which removed 36,126 cu. yds. in 25 days, an average of 1,445 cu. yds. per day.

Road Maintenance in Hertfordshire County, England.*

BY JOHN H. EVANS.†

The County Council of Hertfordshire is responsible for the upkeep and maintenance of nearly every roadway within the county. As a consequence we have two classes of roads under our direct management, with varied conditions of traffic requiring various materials and calling for different methods of repair. The county of Hertfordshire for administrative purposes is divided into eight districts, each of which is in charge of a district main road surveyor, all of whom are responsible to the county surveyor, whose offices are centrally situated at Hatfield. The roads in each district are divided into two classes according to their importance, the main trunk roads being "first class" and the local district roads "second class." These are again subdivided into sections which, in my district, run alphabetically from A to P. Each section is in charge of a working foreman or working foremen, according to mileage and importance. I always make it a point to get, when possible, young, intelligent men, and the best of these are placed upon the most important roads. The men are paid according to the ability shown. I am pleased to say that in my district I have mostly young men whom I have trained, during the period I have been in charge, into really first-rate roadmen, and these men now realize that roadwork is really skilled labor. As the old man (who was originally put to work upon the roads to keep him from applying for parish relief) falls behind, his place is taken by a younger man, who will soon be a skilled workman, and we make it worth his while to take an interest in his work by giving him sick pay for a certain period should he fall ill.

The question of highway administration is one of the most important subjects the municipal engineer has to face at the present time, and its serious nature cannot be too highly regarded. Everywhere throughout the length and breadth of the country the cost of the upkeep of our highways in order to meet the requirements of modern traffic, is increasing to an alarming degree, and a surveyor's position when annual estimates are considered is far from being an enviable one.

Nowadays it does not suffice to apply macadam to a road surface regardless of how that material will wear. It should be applied and consolidated in such a manner as to obtain the maximum wear and best results in every way, and I am strongly of the opinion that in future the different classes of traffic which pass over our roads will have to be considered more closely. It stands to reason that a length of road which carries heavy [illegible] should not be compared with another [illegible] of road maintained with the same material carrying less traffic, neither would it be reasonable to condemn a perhaps cheaper stone because it has not seemingly worn so well as that on another length having less traffic.

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*Abstract of a paper read at the [illegible] meeting of the Institution of Municipal Engineers.

†District Main Road Surveyor, Hertfordshire County Council.

I suggest it is expedient before preparing an estimate for resurfacing a road, and before deciding upon the quality of the material to be used, to find out the actual amount and kind of traffic which daily passes over the surface about to be taken in hand. In my district I occasionaly have the traffic counted. As a matter of fact it has just been taken on the most important and most expensive road—*i. e.*, the main trunk line of road leading from Watford to London through Bushey. The traffic was counted at Bushey, near the village church, for the fortnight ending December 13, 1908 (Sundays included), and we have therefore the total traffic for fourteen consecutive days. A box or hut on wheels was placed in position and the counting done by two men, one commencing at 6 o'clock a. m., and the other (who relieved him) at 3 o'clock p. m., the latter remaining at his post until 12 o'clock midnight. It will thus be seen that the traffic returns are for eighteen hours per day. I explain this owing to the importance of the matter, since, with such a basis to work upon, a surveyor can make a correct estimate of the cost of maintenance on any special length of road. I might add that the amount of traffic over the road just mentioned has very nearly doubled since 1905. Taken in March of that year it was 833 vehicles per day, averaged on a total of six days.

The approximate annual estimate for the current year for the upkeep and maintenance of this particular road is £500 a mile, and the traffic (including a service of motor omnibuses) amounts to 1,253 total average traffic per day for fourteen days (inclusive of Sundays). It will therefore be seen that by taking the record of the traffic we are able, if necessary, to get the approximate cost per vehicle per annum passing over the road, and I consider this means of arriving at the cost of upkeep to be of great importance and worthy of more general adoption. If at some future time the subject of taxing motor and other vehicular traffic has to be considered this information would be of the greatest use to local authorities, and, too, what better defence can the municipal engineer have when heckled upon his increasing estimates than the ability to prove the ever-increasing traffic along his roads?

Having ascertained the amount and nature of traffic, and decided upon the most suitable material to use, the question of the new road surface remains to be decided.

In my district, and I believe throughout the whole of the county of Hertfordshire, a scarifier is unknown. I contend, and perhaps I may be allowed to mention that I speak with an experience of many years in several counties, that a scarifier is a tool not required upon the roads nowadays, certainly not in rural districts, and certainly again not upon 80 per cent of the roads within a town area. I am firmly of opinion that much more harm than good is done by its use, and the sooner it is discarded the better will it be for the roads, the ratepayer and the reputation of the engineer. Within my district, at Watford, a scarifier has not been used since I have been in charge, and I look upon the roadways here with a certain amount of pride, and put them forward as the strongest evidence I can offer in support of my contention.

An ounce of practice is said to be worth a ton of theory, and I am content in striking my own furrow in this connection by forsaking the method of scarifying, as advocated and strictly adhered to by the majority of engineers having charge of highways. I have studied and watched the effect of these tools on old road surfaces, and I am convinced that their use should be discontinued if we are to build up strong and good road surfaces to stand the severe strain of the ever-increasing modern traffic. We all know that the present day road surfaces will not withstand for a great length of time the strain they are called upon to bear, and it is time our highway authorities should be relieved of the expense of such a doubtful process.

Before spreading new material I consider the best course to adopt is to fill up all hollows or uneven parts and render the old surface as even as possible by rolling. The new material is then applied in the ordinary way, care being taken to see that every shovelful is well and evenly spread, and thoroughly dry-rolled until every stone is dovetailed and firmly laid before the binding material is applied. Only enough (and as little as possible) of this material should be used to cement the new surface, after which clean ⅝-in. chippings should be spread lightly and swept about, the roller being allowed to finish the work. We use various kinds of material for binding purposes, but always exercise due care to see that it is clean. I make it a rule to carry out this work in short lengths, doing half the roadway at a time and leaving the other half for the use of the traffic. By reserving half the roadway in this manner a far better surface is obtained, as the new work is not interfered with until it is well consolidated. Special attention is given to the dry-rolling before the binding is applied. This is very important, and very little water is used at any time. I always endeavor to repair the main trunk roads which have the heaviest traffic during the summer months, so that every chance is given them to dry quickly.

Briefly, this is our system of new coating, always tabooing a scarifier; but upon hills I find it necessary slightly to score the surface before spreading the material, in order to prevent slipping. This scoring is done diagonally from the center to the sides, in lines about 12 in. to 18 in. apart. When patching becomes necessary it is carried out in a similar manner, but with a smaller gage material. As soon as a hollow the size of a saucer appears, the roadman fills it with small stone (not chippings), and care is taken neither to disturb nor loosen the surface previously in any way. All the men are provided with light birch brooms—the use of a road rake is sternly forbidden, since that to my mind is another tool out of date—and every day until the patch has been consolidated the broom is lightly used to keep the small stones in their proper places. For this patching work 1¼-in. material should be used. I need scarcely add that the roads are carefully examined for the "saucers," and when the least sign appears of their existence, attention is immediately given to them. A wheelbarrow of this small stone goes a long way, probably about 10 tons to the mile being used for this purpose.

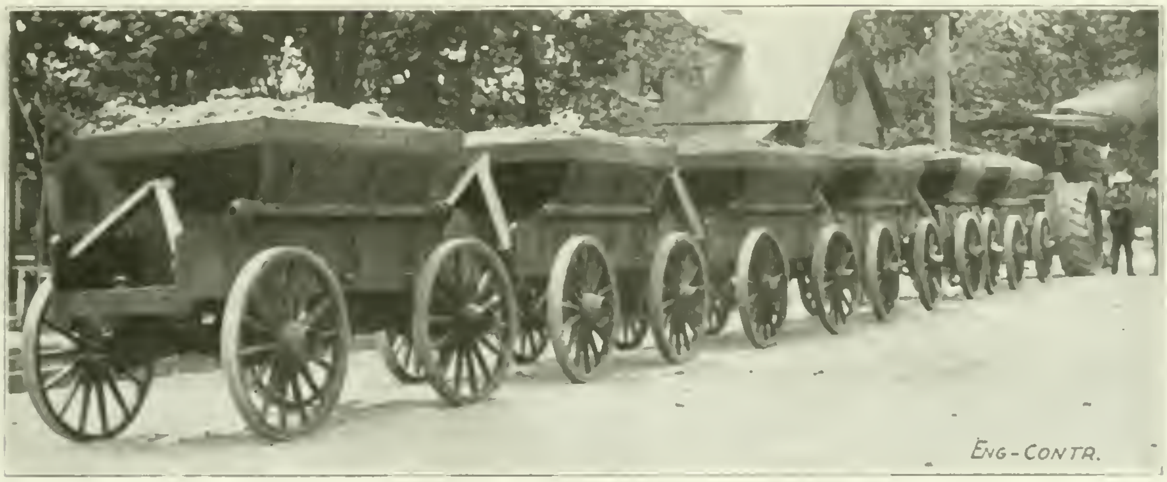
Many of you may question the efficacy of our mode of maitenance. To those I say "come and see the roads." I believe, and I speak from experience, that we obtain a greater amount of wear out of our material by adopting this manner of mending, and I know that we get a better and clearer surface—a fact much appreciated by the public. My remarks apply to all kinds of materials, the better class being used, of course, upon the roads carrying the heavier traffic, and the results are invariably the same.

I have mentioned that very little water is used when consolidating new surfaces, and to my mind far too much is used by the latter-day macadam, accounting to a great extent for the mud to be found upon too many roads. If you have mud in the winter, *ipso facto* you must have dust during the summer. Save your road as much as possible from an excess of moisture when being solidified, and it will be found that the dust nuisance has been to a great extent overcome.

We must all be interested in the cure and prevention of dust upon our highways, and I am far from believing that tar, or, in fact, any material in which tar forms the chief ingredient, is the last word with regard to this problem. Dust upon our highways can never be absolutely abolished; but we can, and must, find the means to reduce it to a minimum. Tar has not as yet had a fair chance of showing its benefits in this direction. In almost every county in England and Wales it has been tried during the past two years, but I venture to think with but indifferent success. When tarring is carried out I suggest it is a mistake immediately to cover it with sand or hoggin. These materials are too fine and too absorbent to answer satisfactorily. Nothing but small, clean, dry chippings should be used if one's efforts are to be attended by success. Not until tar is standardized, as suggested by Mr. Brown, of Nottingham, can it be relied upon for that work, differing so greatly as it does in every district.

Tar which has been highly distilled is unsuitable for painting surfaces, as in the course of distillation many of its oils and other valuable properties are extracted, but all tar should most certainly be dehydrated before use. As the tars obtained from different gasworks differ, so also do they differ in the amount of ammoniated gas water they contain, and in many cases as much as 30 to 40 per cent of water is mixed with this doubtful fluid. I have found newly made-up roadways unsuited for tarring, and I am convinced that a road should be made up at least six to nine months before being painted, if the work is to answer satisfactorily. The pressure by which the tar is applied by some machines I believe to be too great. A pressure of 200 lbs. appears to me ridiculous and a useless strain upon the machine. One of between 50 lbs. and 60 lbs. is ample, and if the machines are incapable of delivering the quantity required with this pressure, then others must be built with pumps of the required capacity. The machines will then last longer and do their work better, and they will not be so liable to get out of order and to hinder the roadmen while the work is in hand. Too much attention is also given to the temperature at which the tar is applied. If the tar has been dehydrated in the first instance, only such a temperature will be required as will render it sufficiently fluid for working, say 150 degs. to 160 degs. Fahr.; but actually to boil the tar before use is a mistake, as it is apt to dry too hard and too quickly before the chippings have had an opportunity of becoming impregnated. There is no doubt that footpaths are greatly improved by being painted with tar. A small machine, having a capacity of about 20 gallons, so simple in character and design as to enable an ordinary roadman to use it seems to be badly needed. Such a machine, constructed to throw or splash the tar upon the path, would answer better than one designed to spray it, as it will be more easily worked. I hope to see the gravel or hoggin footpaths along our country roads tarred by such a machine in the near future. We have used no tarred macadam in this part of Hertfordshire as yet, and so far I am not favorably impressed with the idea of tar being used in the binding of metal when surfacing a roadway. The nuisance arising from dust upon our highways will, it is scarcely necessary to add, never be entirely abated. All we can hope to do is to reduce this menace to public health to a minimum. No matter how skillfully our road surfaces are treated, there will always remain the dust which is in suspension in the atmosphere, which is on trees and hedges, and which blows from adjoining lands to annoy and menace users of the highway.

A Train of Dump Wagons That Can Be Pulled in Either Direction, Thus Not Requiring Turning Around.



A Train of Reversible Dump Wagons Hauled by a Traction Engine.

Wagons hauled in trains by a traction engine present no great novelty, altogether it is astonishing how seldom this economic method of transportation is used. But there is a feature of decided novelty in the train of wagons shown in the accompanying picture. These wagons can be pulled backward as readily as they can be pulled forward thus making it unnecessary to turn the train of wagons around to make the return trip. This is especially advantageous in road building, where space in which to turn a train of wagons is frequently not available. In such cases the traction engine is unhooked from one end of the train, turned around and hooked on to the other end of the train of wagons. During the time the traction engine is being turned, all the wagons can be dumped by one man, who can make the wagons entirely ready for the return trip.

A train of these wagons will turn a sharp corner and follow the traction engine wherever it may go.

The photograph shows 6 wagons, each holding more than 3 cu. yds. of broken stone.

Not many road builders realize the saving that can be effected by the use of a traction engine in hauling stone. Using teams, the cost of hauling stone for a macadam road is rarely less than 25% of the total cost of each cubic yard of macadam measured in place, the haul being only 1½ miles. In fact, due to the present high charge for teams the cost is usually very much more.

The manufacturers of this wagon make the very modest claim that it will save at least 30 to 50% of the cost of hauling. We know of no instance where the saving by traction hauling has not been much greater than this claim, but assuming a saving of only 40% of the cost of hauling by the use of a train of dump wagons and a traction engine, we have 40% of 25%, or 10% saved on the total cost of the macadam. This in itself is a nice profit on the whole job, although it is really but the profit obtained by applying up-to-date methods to one single item.

This new type of reversible dump wagon is made by the Troy Wagon Works Co., of Troy, Ohio.

Calcutta, India, has awarded the contract to an English firm for a large elevated water tank for the continual supply of filtered water. The tank is to be 15 ft. deep by 321 ft. square, supported on steel columns 100 ft. above the ground level. The tank is to have four compartments, which can be used independently of each other, and will store for use 9,000,000 gallons of water. The amount of filtered water consumed per head daily in Calcutta is estimated at 7.5 gallons during the night hours and 75 gallons during the day. The contract was let to Clayton & Son Co., London, England, at $156,666.

The Buenos Aires (Argentina) street cars in 1907 carried 225,010,716 passengers, the receipts being about $10,000,000 gold. Only 7,338,563 of the passengers were carried in horse cars.

The total number of persons at work on the Isthmian Canal on Jan. 27 was 21,878.

Railway Section

Note: This section is devoted to methods and costs of constructing railways. It will cover road-bed and track construction, contractor's plant and organization, surveying methods and permanent way structures.

An Analysis of the Appraisal of the Railways of Minnesota with Comments on the Same.

We had hoped to be able to present in this issue of Engineering-Contracting abstracts of the reports of the chief engineers of two railway commissions, namely the report of Mr. Dwight C. Morgan to the Railroad and Warehouse Commission of Minnesota and the report of Mr. Halbert P. Gillette to the Railroad Commission of Washington. Mr. Morgan's report was submitted Nov. 30, 1908, and has just been published. Mr. Gillette's report was submitted a year ago but its publication has been delayed.

The two reports present many interesting contrasts in methods used in attacking the same problem, and, for that reason as well as because they are the first appraisals ever made for railroad commissions as a basis for railroad rate making, it was desirable to present them simultaneously. However, there are so many of our readers who will be interested in the methods and data given in Mr. Morgan's report that we present a summary in this issue, as follows, condensing the explanations of methods into our own language.

Mr. Morgan began the appraisal of the Minnesota railways Jan. 15, 1906, and rendered his report Dec. 1, 1908, the work having occupied almost three years, during which time 7,596 miles of railways were appraised. The method of making the appraisal was essentially the same as that used by Mr. William D. Taylor, engineer of the Wisconsin Tax Commission, who made an appraisal of Wisconsin railways for taxation purposes.

This method is what might be called the co-operative method of appraisal, because the railway companies are asked to co-operate with the railway commission, and, indeed, are required to submit their own detailed estimate of costs to the commission. The theory is that the commission is thus saved much unnecessary labor, and has merely to check over the estimates of the railways. In practice, however, it is our opinion that the engineers of the railway commission must either accept the returns of the railways without question or else spend almost as much time and labor in checking the estimate as was originally made by the railways in preparing it.

Blank forms were furnished to all the railways, upon which they were required to enter their detailed estimates. Two estimates were required, one giving the "cost of reproducing the property *new*. The other giving the "present value of the physical properties." The "cost of reproduction" means the cost of reproducing the property *new*. The "present value" is the depreciated or second-hand value, ascertained by deducting depreciation from the "cost of reproduction."

The unit prices used by Mr. Morgan were the average prices for the year 1905, which, he states, were about an average of the prices for the five-year period ending June 30, 1907.

In estimating the various railway lines, sections of about 100 miles were taken, but the "terminal properties" in St. Paul, Minneapolis and Duluth were treated as separate sections.

In valuing the lands, Mr. Morgan did not wait for a report from the railways, but started an independent investigation at once. Special agents were appointed to ascertain the value of lands adjacent to all railway lines. These agents examined and noted more than 55,000 bona-fide sales of property, involving considerations of $100,000,000, and representing 1,300,000 acres of land. To do so they examined the records of the transfer of property for several years prior to Jan. 1, 1900, for a distance of 1½ miles on each side of each railway line, using the official county records for information.

The figures thus ascertained were platted on maps, which facilitated arriving at values per acre in any given section. This, in our judgment, was an excellent procedure, but it has a serious defect. No such records can be introduced in court, for the reason that records of property transfers are often falsified as to values by the parties engaged in the transfer. However, such data form an excellent guide to the judgment of the experts engaged in determining land values, particularly where the opinions of people differ widely as to such values.

Having ascertained the value of lands adjacent to the railways, the next step is to multiply these values by some factor to arrive at the value of land for "railway purposes." Mr. Morgan says, in his report:

"The purchase of lands for a railroad right-of-way requires the consideration of two elements: First, the fair value of the land taken, and, second, the damage to the residue in consequence of a part of the tract having been taken for railroad purposes. The element of damage is dependent upon a variety of conditions, several of which may be mentioned as, the location and direction of the proposed railroad with respect to the boundaries of the property; the inconveniences and dangers likely to be suffered and attributable to the construction and operation of the line, such as the separation of the owner's house from his barn, or of his barn from his well. The influence of public opinion for or against the construction of a line of railway is a most potent factor in respect of cost [If one railway already exists, a projected second railway nearby will have to pay much higher prices for land, due to the fact that land owners do not feel the necessity of a second road and will "hold up" the new railway for the highest possible prices.—Editor.] In varying degrees, these and other considerations make the lands purchased for a railway right-of-way usually more costly than the true or normal value of lands for other purposes."

Mr. Morgan goes on to say that his agents had examined the bona-fide sales of lands to railway companies, covering the more recently constructed lines, involving 7,000 acres and an expenditure of $4,200,000 in acquiring them in various parts of the state. As a result of this investigation and of a study of the whole subject, the conclusion was reached that a multiple of 3 should be used in converting the normal value of right-of-way lands to the "value for railway purposes." This multiple of 3 was not applicable to lands in the large terminals, St. Paul, Minneapolis and Duluth.

Mr. Morgan calls attention to an illuminating instance of the high cost of land acquired by condemnation as compared with the cost of land purchased by agreement. On the Illinois Central, in the counties of Mower and Freeborn, about 35 per cent of the right-of-way was secured by condemnation proceedings and the company paid 4½ times the normal value of the land. The remaining 65 per cent purchased by agreement cost only 1.7 times the normal value of the land.

The multiples used in arriving at the values of terminal property for railway purposes were as follows: For St. Paul, 1.75; for Minneapolis, 1.60; for Duluth, 1.25. In other words, the normal value of the bare land (not including buildings) in St. Paul was multiplied by 1.75 to obtain the "value for railway purposes." These multiples were arrived at as follows: The sessed at about 60 per cent of its selling railway terminals were ascertained. Investigations made (in 1906) by a special tax committee of the city council of St. Paul had shown that property was assessed at about 60 per cent of its selling price. Hence the assessed value of property adjacent to the terminals in St. Paul was divided by 0.6 (or multiplied by 1.66) to arrive at its normal value. This normal value was then multiplied by 1.75 to arrive at its "value for railway purposes."

The multiples of 1.75 for St. Paul, 1.60 for Minneapolis and 1.25 for Duluth were based upon the purchases of real estate by railways in those cities during the preceding six years. During that period more than 320 acres of property had been purchased by railways for about $3,000,000.

Comparing the prices thus paid by railways with the prices paid by other corporations and individuals during the same period, the multiples above given, were arrived at. Fortunately two railway companies had purchased land for terminals in St Paul and one in Duluth during this six year period, so that sufficient data were available to enable Mr Morgan to arrive at a fair decision as to the multiples to be used.

An inspection of the physical property of the railway was made, practically all this inspection being done in a manner that will be regarded as rather superficial by many of our readers. Each railway company provided a special train which carried the inspectors. "The train was moved at a low rate of speed so that observation could be had of the character and standards of construction and maintenance. Stops were made every mile in places, but usually every two miles, and sometimes every five miles, to enable measurements of the roadbed and ballast, to observe the brand, weight and age of the rails and fastenings, to ascertain the average number of ties per mile by test measurements and counts; in fact, to make complete record of all the physical elements at these given points. Additional stops were frequently made at bridges and culverts for the purpose of measurement and inspection, and at all stations measurements of buildings were made, the inventories checked and notes made of any important changes.

"The detailed reports of the railway companies having been compiled on the forms prepared for that purpose, were in such systematic order by subjects as enabled the ready checking of the various items enumerated. The profiles were continually made use of to determine their accuracy * * * Also as to whether sand, gravel, loose or solid rock cuttings, which would later serve as a guide in the classification of material in making the compilations and estimates of quantities in the office."

That this inspection was cursory is shown from the fact that about 100 miles of line were inspected each day of 10 hours from each train.

No inspection of rolling stock was made, as in the Wisconsin appraisal above referred to, but the "equipment reports were checked by the serial numbers of locomotives and cars."

The inspection was begun early in May, 1907, and continued almost without interruption until the middle of December, 1907, completing this feature of the work, "except the range roads, which were examined in the early part of 1908."

The unit prices assumed for estimating costs "are the results of much research." The unit prices submitted by the railways in their reports differed widely, and often in a manner not susceptible of explanation. For example, the price of steel rails varied from $20 to $31.50 per ton f. o. b. St Paul; bridge steel of the same class ranged from 2½ to 4½ cents per pound, locomotives of the same type and weight varied from 6¾ to 12¾ cents per pound, engineering, superintendance and legal expense, between 1½ and 15 per cent, interest during construction, 1 to 12 per cent, contingencies, 5 to 50 per cent.

Mr Morgan selected unit prices to fit the local conditions and did not assume invariable unit prices for all roads, as was done in the Wisconsin appraisal.

"Adaptation and solidification of roadbed," or "seasoning of the roadbed," was regarded by Mr Morgan "as a labor account covering a period of years," and treated as a separate item of cost, although it never appears in the records of any railroad company as a part of the cost of construction. According to the allowance made by Mr Morgan, this item of "adaptation and solidification of roadbed" amounted to $11,713,000 for the 7,596 miles of railways in Minnesota, or $1,545 per mile, or nearly 3% of the grand total cost of construction and equipment.

There is no doubt that the roadbed of a newly built railway requires more labor to maintain and that the cost of running trains of the roadbed is more expensive than after the embankments have settled and land slides and slips have become less frequent; but no two engineers will agree as to what allowance, if any, should be made for the cost of "seasoning." The fact is that much of this "seasoning" is due the action of rain, and costs nothing. Practically all the rest of it is done by the trackmen who are maintaining the track, as a part of operating expenses. The 7,600 miles of railways in Minnesota averaged 23,110 cu. yds. of earth, loose rock and solid rock. Hence, according to Mr Morgan's estimate of $1,545 per mile for "seasoning," it would have cost nearly 7 cts. per cu. yd. for "seasoning" alone. Since earth can be spread and rolled for only a fraction of this 7 cts. per cu. yd., it is evident that most of this $1,545 item of "seasoning" must be due to some other class of work than grading. In giving his reasons for his seemingly large allowance for "adaptation and solidification of roadbed," Mr. Morgan says:

"The newly made excavations wash and slip, the ditches fill from the action of the elements, the embankments settle and the track superstructure is in almost constant need of attention; resurfacing, lining and dressing of ballasted and unballasted track is necessary, waterways become clogged up, bridges settle or go out of line, station grounds are to be improved and finished, scattered and unused material must be picked up and stored; in fact, all the loose ends which are the immediate sequence of construction must be gathered in and the property brought to an orderly condition."

While engineers will never agree as to the exact amount that should be allowed for "seasoning" of roadbed, still the majority would probably favor some allowance in estimating the cost of reproduction of existing railways.

On the other hand there will be found many engineers who will favor any allowance for "contingencies" in estimating the cost of an existing railroad line. Mr Morgan favors a small allowance for contingencies, and, as will be seen below, selected 5% as a fair estimate for this item instead of the customary 10% used on estimates of projected lines. He says:

"Considering the detail with which the estimates have been prepared and the inclusion in them of many items of a contingent nature, it does not appear justifiable to consider an estimate of the cost of reproducing a railway as synonymous with an estimate for constructing a projected line. The essential difference rests in the fact that in reproduction cost the estimate is prepared in the light of known conditions whereas for a projected line the contingencies are wholly unknown. These facts have been instrumental in reaching a determination that 5% for contingencies is fair under the circumstances attaching to the work of this appraisal."

In estimating the item of "interest during construction," Mr Morgan assumed a rate of interest of 4% per annum on the money tied up during construction. "This rate of interest was applied to the total estimated cost of reproduction, assuming that the necessary funds would be fully employed one-half of the estimated time required to build the respective lines, which according to their mileage varied from 1 to 8 years." It will be seen from the data given below that this interest item amounted to about 8.8% of the total cost of reproduction as estimated for all the railways of the state.

The "present value" of each item was arrived at by deducting an estimated percentage of depreciation from the estimated "cost of reproduction." This estimated percentage of depreciation was furnished by hardly any of the railway companies, for they held that no real depreciation had occurred, and that a road is more valuable as a working tool years after its construction than when new. Mr Morgan made his own estimates of depreciation, based upon the inspection above referred to, and thus arrived at the "present value" given below. It will be noted that the total "present value" is about 13% less than the "cost of reproduction."

Mr Morgan did not secure the original cost of construction and betterments, and he states that such data were so incomplete as to render the task hopeless. He says that "for the older and more important railways, representing the greater part of the mileage of the state, the data for some of them is not available at all, and for others it is so incomplete as to render its development for practical use an impossibility."

We believe that Mr Morgan is wrong in this conclusion, for in making the appraisal of the railways of Washington these same arguments were used by the railways, and it was only after a bitter struggle in some cases that access to all their records was secured, which developed that practically all the costs of construction and betterments could be found, even for the lines built forty years ago. Among these Washington lines was the Great Northern, which has nearly 30% of the mileage in Minnesota. Its original records of cost (in the St. Paul office) are exceptionally well kept and complete, as well as its records of betterment costs. If only used as a guide in estimating the cost of reproduction, these original records (both in the accounting department and in the engineering department are practically invaluable Furthermore they are of great value in cases of litigation between the railway commission and the railway company where the accuracy of estimates of cost of reproduction are brought into question.

Another point of great importance is the percentages allowed for contingencies, for interest during construction and for engineering. Mr. Morgan has allowed 5% for contingencies, nearly 9% for interest during construction, and 4½% for engineering, superintendance and legal expense. Each of these percentages alone sounds small, but they aggregate more than $61,000,000 in Mr. Morgan's estimate. So enormous is this sum that the correctness of these percentage allowances becomes a very important matter to the railway companies and to the state. We know of no satisfactory way of determining the correctness of these percentages except by ascertaining from the accounting records of the railways what their expenditures for such items actually have been. A thorough analysis of the accounting records would probably eliminate all of the item of "contingencies," amounting to $17,869,000 in the estimate for Minnesota, for any allowance for "contingencies" is always a confession of ignorance as to what the exact expenditure will be or has been. On the other hand, an analysis of accounting records might disclose that the percentages allowed for interest during construction and for engineering are too low, as claimed by many of the railways. We do not say that such would be the result, but so long as the claim is made and so long as such enormous sums of money are at stake, an analysis of the accounting records of every railroad should be made, even though the records may be incomplete for some of the older lines. It does not cost more than $6 or $7 per mile of road to make such an investigation and analysis of costs of original construction and betterments. Mr. Morgan informs us that his appraisal cost the state of Minnesota $8.50 per mile of main track, but of course, this does not include what it cost the railways to make the estimates which Mr. Morgan's forces checked, nor, as we have stated, did Mr. Morgan make an investigation and analysis of the original cost and betterments. The state of Minnesota has secured an exceedingly valuable estimate at a very low cost, but we can not urge too strongly the desirability of a thorough investigation of the accounting records of the railways and the subsequent use of accounting records in keeping cost estimates up to date.

We pass now to a summary of the data collected by Mr. Morgan:

Mileage in Minnesota.
(June 30, 1907)

	Miles.
Roadway, or 1st main track	7,596
Other main tracks	428
Side tracks	2,414
All tracks, total	10,438

From this it will be seen that there are 1.38 miles of tracks to each mile of roadway. Hence, the subsequent items of cost per mile of roadway must be divided by 1.38 to get the cost per mile of track.

By dividing each of the above items of cost of reproduction by 7,596, we have calculated the itemized cost of reproduction per mile of railway, tabulated below. To convert any of these items into cost per mile of track, divide it by 1.38, as above explained:

Cost of Reproduction per Mile of Roadway.
(7,596 miles.)

1. Land for right of way, yards and terminals	$ 9,637
2. Grading, clearing and grubbing	7,373
3. Protection work, riprap, retaining walls	318
4. Tunnels	33
5. Cross ties and switch ties	2,302
6. Ballast	1,240
7. Rails	4,345
8. Track fastenings	782
9. Switches, frogs and railroad crossings	183
10. Track laying and surfacing	703

COST OF REPRODUCTION AND PRESENT VALUE (7,596 MILES OF ROADWAY).

	Cost of Reproduction New.	Present Value.
1. Land for right of way, yards and terminals	$ 73,201,757.70	$ 73,201,757.70
2. Grading, clearing and grubbing	56,006,782.11	56,006,782.11
3. Protection work, rip rap, retaining walls	2,419,292.42	2,419,292.42
4. Tunnels	253,250.00	253,250.00
5. Crossties and switch ties	17,491,500.06	9,627,539.85
6. Ballast	9,413,351.34	9,413,351.34
7. Rails	33,010,087.72	25,199,668.20
8. Track fastenings	5,936,740.60	4,543,054.70
9. Switches, frogs and railroad crossings	1,389,363.52	962,741.45
10. Track laying and surfacing	5,340,689.05	5,340,689.05
11. Bridges, trestles and culverts	19,567,524.80	14,518,834.30
12. Track and bridge tools	201,918.21	151,438.71
13. Fences, cattle guards and signs	2,768,394.93	1,403,082.54
14. Stockyards and appurtenances	559,896.21	349,759.71
15. Water stations	1,606,164.62	1,144,535.43
16. Coal stations	717,519.88	507,703.49
17. Station buildings and fixtures	5,855,258.56	4,097,249.08
18. Miscellaneous buildings	4,344,684.37	3,403,171.52
19. Steam and electric power plants, gas plants	797,484.52	656,069.99
20. General repair shops	4,123,119.91	2,959,019.07
21. Shop machinery and tools	1,831,671.22	1,484,756.11
22. Engine houses, turntables and cinder pits	2,837,988.58	1,874,436.40
23. Track scales	184,130.00	129,474.45
24. Docks and wharves (incl. coal and ore docks)	6,065,496.69	5,392,960.85
25. Interlocking plants	403,071.57	293,197.56
26. Signal apparatus	155,766.71	126,217.89
27. Telegraph lines and appurtenances	1,316,048.16	994,227.19
28. Telephone lines and appurtenances	94,526.17	70,926.17
29. Adaptation and solidification of road bed	11,743,007.15	11,743,007.15
Total of items 1 to 29 inclusive	$269,636,486.78	$238,230,206.93
30. Engineering, superintendence, legal expense, 4½%	12,133,641.89	12,133,641.89
Total of items 1 to 30 inclusive	$281,770,128.67	$250,363,848.82
31. Locomotives	17,090,953.40	12,608,422.67
32. Passenger equipment	6,616,170.78	4,554,442.63
33. Freight car equipment	46,911,106.58	34,068,095.26
34. Miscellaneous equipment	1,326,666.16	876,057.17
35. Marine equipment	43,500.00	32,625.00
Total of items 1 to 35 inclusive	$353,758,525.59	$302,503,491.55
36. Freight on crossties, rails, fastenings switches and frogs	3,635,535.03	3,635,535.03
Total of items 1 to 36 inclusive	$357,394,060.62	$306,139,026.58
37. Contingencies, 5% on total of items 1 to 36	17,869,703.02	17,869,703.02
38. Stores and supplies	5,210,010.98	5,210,010.98
39. Interest during construction	31,261,419.93	31,261,419.93
Grand total	$411,735,194.55	$360,480,160.51

It will be noted that the cost of reproduction and the present value of item 36 (freight on track materials) are identical; but since freight is a part of the cost of these materials delivered, and since the materials depreciate, the present value of item 36 should be less than the cost of reproduction. The error in this case arises from the segregation of freight as a separate item, which should not be done.

Item 37 (contingencies) is a percentage of all the previous items. It is not clear why contingencies should be figured on lands, nor on equipment.

11. Bridges, trestles and culverts	2,576
12. Track and bridge tools	27
13. Fences, cattle guards and signs	364
14. Stock yards and appurtenances	74
15. Water stations	211
16. Coal stations	95
17. Station buildings and fixtures	772
18. Miscellaneous buildings	572
19. Steam and electric power plants, gas plants	105
20. General repair shops	543
21. Shop machinery and tools	241
22. Engine houses, turntables and cinder pits	373

23	Track scales	21
24	Docks and wharves (inc. coal and ore docks)	779
25	Interlocking plants	53
26	Signal apparatus	20
27	Telegraph lines and appurtenances	173
28	Telephone lines and appurtenances	13
29	Adaption and solidification of roadbed	1,546
30	Engineering, superintendence and legal expense	1,598
	Total of items 1 to 30 inclusive	$37,095
31	Locomotives	2,250
32	Passenger equipment	872
33	Freight car equipment	6,175
34	Miscellaneous equipment	175
35	Marine equipment	6
36	Freight on cross ties, rails, switches and frogs, track fastenings	478
37	Contingencies	2,352
38	Stores and supplies in Minnesota	686
39	Interest during construction	1,115
	Grand total	$51,204

The details of item 1 (land) are as follows per mile of roadway:

12.636 acres right of way	$1,217.90
0.620 acres gravel pits, etc	33.42
2.973 acres station grounds	1,538.28
0.638 acres terminals (St Paul, Minneapolis and Duluth)	6,846.81
16.866 acres total	$9,636.31

These values are not the "normal values" of the land for ordinary purposes, but the "values for railway purposes" as ascertained by applying the multiples above given.

The most significant fact in this land appraisal is the very high percentage that the land for terminals forms. Station grounds also form a large percentage of the total cost for lands. There are many states in which such expensive terminals do not exist, and there are others like Illinois, Pennsylvania and New York, where the cost of terminals is probably greater per mile of railway.

The details of item 2 (grading, etc.) are as follows per mile of roadway:

22,230 cu. yds. earth at 28.7 cts.	$6,380.01
565 cu. yds. loose rock at 51.62 cts.	291.65
345 cu. yds. solid rock at $1.077	371.57
4.56 acres clearing and grubbing at $69.85	318.52
Total	$7,361.75
Grade revision at Owatonna ($27,625)	13.63
Total	$7,375.38

Mr Morgan's report contains no further data as to unit costs.

The itemized costs of each of the different railways in Minnesota are given in the report, and it was from a summary of these items that the above given totals and averages were prepared.

For purposes of comparison, many of our readers will want to refer to similar data on railway appraisals. The following references to articles in ENGINEERING-CONTRACTING cover all railway appraisal data, except for the state of Texas, which we shall give subsequently.

For summaries of the Michigan and Wisconsin railways, made for the tax commissions of those states, see our issue of June 22, 1907.

For an itemized statement of the cost of the C. M. and St. P. in South Dakota, see our issue of July 24, 1907.

For an itemized statement by the chief engineer of the Northern Pacific Railway covering the cost of all its lines, see our issue of April 15, 1908.

Ditto for the Great Northern, see our issue of May 6, 1908.

Within a few weeks we hope to publish the itemized cost of all the railways in the State of Washington. In doing so, we shall give not only the estimated cost of reproduction new and present value, but the actual cost to the railways of that state. These latter figures will be particularly interesting, since nothing of the kind has ever been published before.

We append a table prepared by the Railway Age Gazette from the data contained in Mr Morgan's report.

MILEAGE, CAPITALIZATION AND VALUATION OF MINNESOTA RAILWAYS

Railways	Mileage in Minnesota	Minnesota share of capital stock and funded debt.	Railways' estimate cost reproduction, 1906.	Commission's estimates "A" cost reproduction, 1907	"A" Present value, '07	"B" cost reproduction, 1907.	"B" Present value, '07.	Capital per mile in Minn.	Est. cost reproduction per mile Railway's 1906.	Est. cost reproduction per mile Com's. estimate "A," 1907
Chi., Bur'ton & Quincy	23.5	$757,242	$2,957,221	$2,726,670	$2,105,988	$2,451,931	$2,131,250	$32,278	$126,054	$116,226
Chicago Great Western	118	16,743,875	17,639,880	7,769,914	6,714,147	6,595,116	5,539,349	142,392	150,012	66,076
Chic., Mil. & St. Paul	1,202	43,371,044	54,888,175	51,591,393	47,459,752	46,159,470	39,327,829	36,083	45,665	47,418
Chi. & North Western	651	25,068,954	20,911,139	21,214,978	17,463,934	18,154,144	14,790,100	38,492	32,113	32,574
Chi., Rock Island & Pac.	236	12,095,605	11,280,105	8,716,215	7,779,600	7,493,711	6,577,096	51,207	47,755	36,904
Chi. St. P. Minn. Oma.	431	16,717,540	29,217,691	26,778,560	22,838,120	22,553,406	18,612,966	38,777	67,772	62,113
Duluth & Iron Range	241	14,232,000	27,267,140	20,564,552	17,771,796	19,226,745	16,433,990	59,095	113,221	[illegible]
Duluth, Missabe & Nor.	142	13,155,500	24,031,984	23,087,672	20,909,116	22,328,569	20,150,013	92,565	169,096	[illegible]
Duluth & North Eastern	63	500,000	665,582	859,865	711,737	791,196	643,368	7,874	10,481	13,741
Duluth & Nor. Minn.	35	200,000	968,039	880,008	675,956	836,477	632,125	5,714	27,658	25,143
Great Northern	2,050	78,268,492	134,823,938	107,074,102	94,115,313	95,406,976	82,748,216	38,181	65,770	52,233
Mason City & Ft. Dodge	27	3,237,425	1,625,205	772,072	622,941	690,926	541,795	118,587	59,531	28,281
Minn. & International	174	2,645,000	1,914,057	3,966,309	3,409,461	3,709,605	3,152,757	15,160	28,338	22,732
Soo	540	18,255,913	20,992,511	21,990,682	19,575,254	19,392,345	16,976,876	33,834	38,906	40,756
Minneapolis & St. Louis	278	20,884,937	21,845,196	16,622,245	14,276,189	14,185,150	11,839,093	55,184	57,721	44,921
Northern Pacific	967	55,898,480	86,817,468	69,397,955	61,099,563	60,679,409	52,381,010	57,801	89,772	71,763
Wisconsin Central	24	1,235,380	1,238,211	2,780,323	2,455,906	2,201,481	1,877,064	52,389	179,586	[illegible]
West Minn. & Pacific	244	10,539,656	11,959,545	6,561,652	5,645,689	5,763,947	4,847,982	43,190	49,008	26,889
Illinois Central	30	1,172,648	819,541	944,302	800,847	798,458	655,001	38,868	27,164	31,300
Duluth, Un. Depot & Ter.	0.4	......	1,018,170	910,698	817,541	821,545	728,288		2,578,217	2,888,135
Minneapolis Eastern	0.9	......	969,161	987,460	847,488	639,268	589,206		1,023,101	947,688
Minneapolis Union	3	......	7,773,750	4,321,250	4,021,728	3,364,427	3,064,904		2,955,798	1,643,061
Minneapolis Western	2	......	1,745,899	1,078,831	966,210	849,883	737,262		1,043,076	638,562
St. Paul Union Depot	0.6	......	5,495,150	4,354,202	4,184,311	2,847,343	2,677,453		9,812,767	[illegible]
Minnesota Transfer	12	......	5,777,987	2,873,283	2,591,546	2,332,762	2,051,027		462,239	229,863
Total	7,587	....	500,675,781	411,735,195	360,480,161	360,951,548	322,567,107			

Note—Average capitalization of railways in Minnesota (except the six switching roads, last-mentioned in table) $44,286 per mile; average cost of reproduction of 19 carrying roads, as estimated by themselves, 1906, $65,009 per mile; Commission's estimate "A," cost of reproduction of carrying roads, 1907, $52,130 per mile; Commission's estimate "A," present value, $45,799 per mile; Commission's estimate "B," cost of reproduction of carrying roads, 1907, $16,202 per mile, estimate "B," present value, $39,571 per mile; average valuation placed on six switching roads (last mentioned) by roads themselves, $1,216,152 per mile; Commission's estimate "A," cost of reproduction of switching roads, 1907, $770,933 per mile, estimate "A," present value, $717,161 per mile; Commission's estimate "B," cost of reproduction of switching roads, $579,718 per mile, estimate "B," present value switching roads $527,945 per mile. Estimate "A" differs from "B" in that the values of lands in estimate "A" are taken at their "value for railway purposes," whereas in the "B" estimate the "normal value" of the land is assumed.

The Chilean Government opened proposals on March 1 for the construction of the railway between Arica, Chile, and La Paz, Bolivia. The work is divided into five sections, viz.: (a) from Arica to the 50th kilometer, (b) from the 50th to the 115th kilometer, (c) from the 115th kilometer to the Bolivian frontier, (d) from the Bolivian frontier to the 155th kilometer, (e) from the 155th kilometer to La Paz. Bids for this work were originally to have been opened Dec. 1.

It is estimated that the production of [illegible] and Lake copper in 1908 from mines located in the United States will be greater by about 50,000,000 lbs., or between 5 and 6 per cent, than that of 1907, which was [illegible] lbs.

Bridges, Buildings and Foundations

Note: This section is devoted to methods and costs of constructing steel and masonry bridges and buildings and of foundation work of all kinds. It will give special attention to erection plant and tools, falseworks and centers and cost data of all kinds.

The Standard Reinforced Concrete Culvert Construction of the Iowa State Highway Commission.

The plans for concrete culverts and highway bridges which are illustrated by the accompanying Figures 1 to 4, are examples of the standard plans worked up by the Iowa State Highway Commission and supplied to county road officials on request. The full set of standard plans includes many more sizes of structures, but as they are all of the same general type we have not thought it necessary to illustrate more than those shown. For these illustrations and for the data which follow we are indebted to Mr. T. H. MacDonald, highway engineer, Iowa State Highway Commission, Ames, Iowa.

Besides the standard plans, the commission furnishes specifications and instructions for materials and construction. For large bridges, standard specifications, it is considered, will not prove applicable without the addition of many specific clauses, and they are not furnished; but for smaller structures, particularly for concrete slab culverts, general specifications can be used that prove fairly satisfactory for covering the work of a township or a county. The following data are taken from specifications as prepared by the commission. A table has been prepared and is included, Table I, which shows the thickness, the amount of reinforcing in square inches per foot of width, the stress in the concrete and in the steel for culvert slabs from 2 to 20 ft. clear span. The loading used is the dead load, which includes the weight of the concrete and the earth fill plus a concentrated live load of a 12-ton traction engine mounted on axles, 11 ft. centers, the rear axle carrying a weight of 8 tons.

The classes of concrete specified for culverts are as follows:

Class A for Tops.—1 cement, 2 sand and 4 broken stone or screened pebbles passing a 2-in. ring.

Class B for Side and Wing Walls.—1 cement, 2½ sand and 5 broken stone or screened pebbles passing a 2½-in. ring.

Class C for Foundations and Footings.—1 cement, 3 sand and 6 broken stone or screened pebbles passing a 2½-in. ring, or Class B concrete may be used.

Class B Mortar.—1 cement and 2½ sand passing a ¾-in. mesh.

Regarding the use of unscreened gravel the specifications state that it may be used for Classes B and C concrete, subject to frequent tests by the engineer to determine the sand and pebble content, and in no

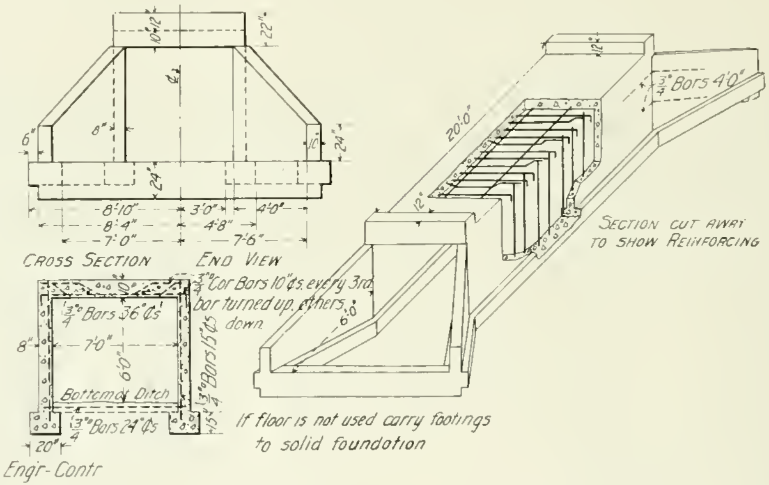


Fig. 1—Standard Plans for 7-Ft. Reinforced Concrete Culvert.

TABLE I.—SHOWING THICKNESS, MOMENTS, COMPRESSIVE STRESSES AND AREAS OF STEEL FOR SLABS OF VARIOUS SPANS AND VARIOUS DEPTHS OF FILL AND A LIVE LOAD OF ONE 12-TON TRACTION ENGINE.

Clear Span. Feet.	Effective Span. ft. in.	1 Ft. Fill.				2 Ft. Fill.				3 Ft. Fill.				4 Ft. Fill.			
		D	M	C	S	D	M	C	S	D	M	C	S	D	M	C	S
2	2-6	6	1387	530	0.30	6	1465	560	0.32	6	1293	494	0.28	6	1085	413	0.24
3	3-6	7	2038	497	0.35	7	2192	530	0.38	7	1865	453	0.32	7	1746	424	0.30
4	4-6	8	2757	467	0.40	8	3010	509	0.43	8	2650	448	0.38	8	2550	432	0.38
5	6-0	9	3903	485	0.48	9	4355	542	0.54	9	4035	501	0.50	9	4020	500	0.50
6	7-0	9	4730	589	0.58	10	5490	523	0.59	10	5150	490	0.55	10	5220	198	0.56
7	8-0	10	5800	552	0.62	11	6700	504	0.64	11	6410	482	0.62	11	6585	496	0.63
8	9-6	11	7430	559	0.71	12	8710	531	0.75	12	8535	520	0.74	12	8930	545	0.77
9	10-6	12	8700	531	0.75	13	10260	517	0.80	13	10300	520	0.81	13	10750	543	0.84
10	11-6	13	10100	510	0.79	13	11760	593	0.92	14	12040	510	0.87	14	12805	542	0.92
11	12-6	13	11350	573	0.89	14	13560	574	0.97	14	13800	583	0.99	15	15010	542	0.99
12	13-6	14	13020	550	0.93	15	15570	563	1.03	15	16010	578	1.06	16	17550	546	1.08
13	14-6	15	14800	535	0.98	16	17750	552	1.09	16	18425	573	1.13	17	20240	548	1.16
14	15-6	15	16370	591	1.08	17	20120	544	1.15	17	21040	570	1.21	18	23180	552	1.24
15	16-6	16	18450	574	1.13	18	22700	541	1.22	18	23850	568	1.28	19	26360	557	1.33
16	17-6	17	20700	560	1.19	18	25050	597	1.35	19	26960	570	1.36	20	29900	562	1.43
17	18-6	18	23150	551	1.24	19	27950	591	1.41	20	30230	569	1.44	21	33680	568	1.52
18	19-6	18	25180	599	1.35	20	31150	586	1.49	21	33780	570	1.53	22	37620	574	1.61
19	20-6	19	27950	591	1.41	21	34550	583	1.56	22	37650	574	1.61	23	42060	581	1.72
20	21-6	20	30950	583	1.48	22	38150	581	1.64	23	41710	577	1.71	24	46640	589	1.82

Clear Span. Feet.	Effective Span. ft. in.	5 Ft. Fill.				6 Ft. Fill.				7 Ft. Fill.				8 Ft. Fill.			
		D	M	C	S	D	M	C	S	D	M	C	S	D	M	C	S
2	2-6	6	1022	390	0.22	6	1027	392	0.22	6	1035	390	0.22	6	1068	407	0.23
3	3-6	7	1728	420	0.30	7	1755	425	0.30	7	1819	442	0.31	7	1899	461	0.33
4	4-6	8	2580	437	0.38	8	2671	452	0.38	8	2808	474	0.40	8	2968	503	0.43
5	6-0	9	4170	519	0.51	9	4405	548	0.54	9	4705	585	0.58	10	5083	485	0.55
6	7-0	10	5480	522	0.59	10	5840	557	0.63	10	6277	598	0.68	11	6818	513	0.65
7	8-0	11	6985	526	0.67	11	7500	564	0.72	12	8190	199	0.71	12	8830	538	0.76
8	9-6	12	9585	584	0.82	13	10510	530	0.82	13	10480	530	0.82	13	11320	572	0.89
9	10-6	13	11600	585	0.91	14	12800	541	0.92	14	13925	589	1.00	15	15215	550	1.01
10	11-6	14	13870	586	0.99	15	15300	552	1.01	16	16900	527	1.04	16	18320	570	1.12
11	12-6	15	16340	590	1.08	16	18100	563	1.11	17	19970	540	1.14	17	21975	595	1.26
12	13-6	16	19130	595	1.17	17	21200	573	1.21	18	23445	559	1.26	19	25675	543	1.30
13	14-6	17	22110	597	1.27	18	24600	586	1.32	19	26950	569	1.36	20	29830	561	1.42
14	15-6	19	25750	544	1.30	19	28200	597	1.43	20	31190	588	1.49	21	34280	579	1.55
15	16-6	20	29380	553	1.40	21	32600	550	1.47	21	35620	599	1.61	22	39140	598	1.68
16	17-6	21	33320	562	1.51	22	37000	564	1.59	23	40840	566	1.67	24	44890	567	1.75
17	18-6	22	37560	572	1.61	23	41700	576	1.70	24	46020	580	1.80	25	50440	582	1.88
18	19-6	23	41990	581	1.72	24	46600	587	1.82	25	51490	595	1.92	26	56500	597	2.02
19	20-6	24	46920	592	1.83	26	52700	557	1.89	27	58060	567	1.99	28	63650	575	2.09
20	21-6	26	52760	558	1.89	27	58500	571	2.01	28	64440	582	2.12	29	70510	590	2.24

D = Depth of beam in inches. M = Max. mom. in ft. lbs. C = Compressive stress in concrete in lbs. per sq. in. S = Area of steel in sq. in. per ft. of width.

case shall the sand be greater than the class requirements or less than is necessary to fill the voids in the pebbles. The approximate quantities for a cubic yard of concrete of the above proportions are given by Table II.

Table II.—Quantities of Materials in Concrete.

Kind	Cement Bbls.	Sand Cu. yd.	Screened pebbles Broken stone Cu. yd.
Class A	1.57	0.44	0.88
Class B	1.25	0.46	0.92
Class C	1.10	0.47	0.94

Note.—It shall be permissible for the inspector to slightly vary the above proportions of sand and aggregate for the different classes to secure a denser concrete with the materials used.

We quote Mr. MacDonald on further matters as follows:

"It will be noticed that we do not adhere strictly to the exact amount of aggregates in the various classes where the materials can be used to produce a smoother concrete by slightly adjusting the amounts as given. The class C concrete is the weakest concrete that we use and at the present price of cement we believe it is false economy to use a leaner mixture except in very heavy construction, and even then we prefer a fairly rich concrete with one man rubble stone imbedded in this concrete. The division line between sand and gravel is placed at about a No. 8 screen and the advisability of following the specification in regard to determining the sand and pebble content is well illustrated by Table III, which gives the results of tests made on samples sent in from various counties":

Table III.—Proportions of Sand and Pebbles in Various Gravels.

Gravel	No.	Pebbles. Pct.	Sand Pct.
Greene County	1	80.8	19.2
	2	46.3	53.7
	3	34.3	65.7
	4	43.0	57.0
	5	57.1	42.9
Carroll County	1	33.8	66.2
Story County	1	58.7	41.3
	2	47.3	52.7
	3	42.4	57.6
Emmet County	1	65.2	34.8
	2	30.4	69.6
	3	51.7	48.3

"A variation in the compressive strength of these samples mixed in a proportion 1 part cement to 6 of the sample is illustrated by the seven and twenty-eight day test given in Table IV:

Table IV.—Compressive Strength of Gravel Concrete.

Gravel	No.	7 days. 1-6 Lbs. sq. in.	28 days 1-6 Lbs. sq. in.
Greene County	1	625	1,030
	2	774	1,490
	3	636	1,170
	4	475	865
	5	577	1,195
Carroll County	1	704	1,137
Story County	1	720	1,487
	2	735	1,370
	3	531	1,275
Emmet County	1	940	1,950
	2	389	744
	3	465	873
Average		612.6	1,215.3

"Without going into this subject too much in detail, it is perhaps worth while to include the following specification for the reinforcing steel:

"'Reinforcing Steel.—Except as otherwise specifically stated herein, all reinforcing steel used shall be of such a section as to provide a mechanical bond at frequent intervals and to insure a thorough contact between the steel and concrete. Net sections, sizes and distribution and bonding shall be exactly as shown on the drawings. The transverse bars shall consist of ½-in. round rods placed in pairs as shown on the drawings, and connected by a lattice bar of the required length, punched with 5/8-in. holes and placed at intervals of 3 ft. The lattice bars shall be keyed to position by a small iron nail. Each bar shall be held rigidly to position by blocking to the forms and wiring to the bars it crosses. Medium steel, having an elastic limit not less than 32,000 lbs. per sq. in. shall be used, and shall withstand cold bending around twice the diameter of the test piece without fracture. Only steel free from rust, dirt and grease shall be used, and some means shall be provided for cleaning the steel before placing.'"

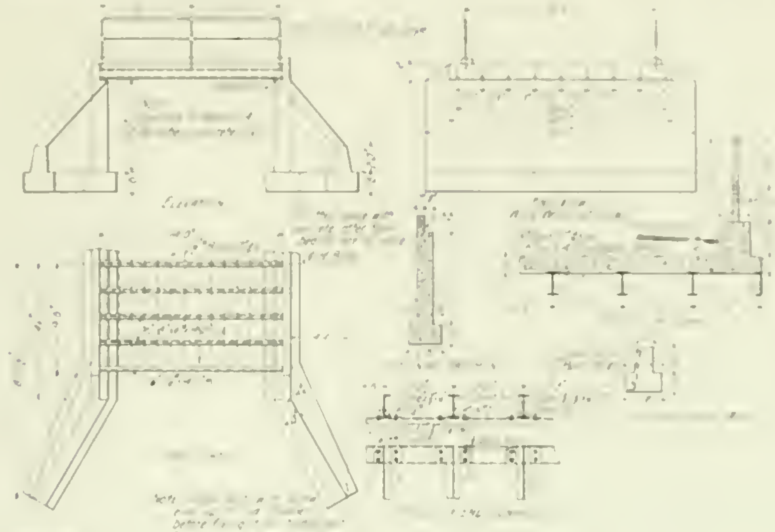


Fig. 2—Details of 14-Ft. I-Beam and Concrete Bridge.

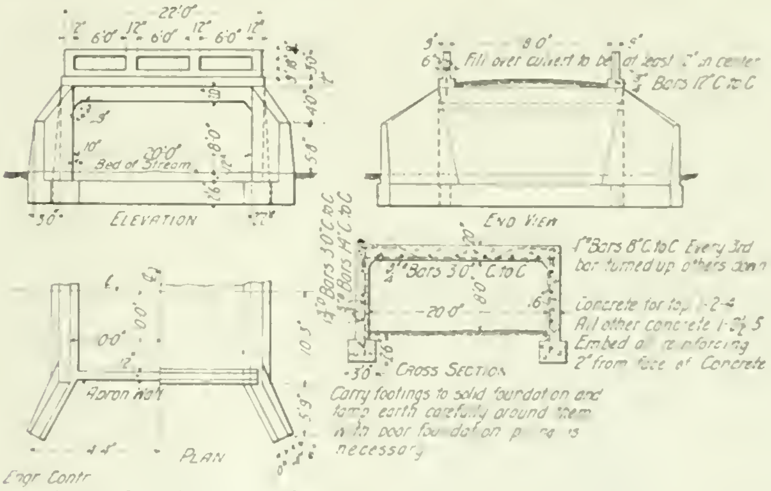

22'0"
6'0"
12"
6'0"
12"
6'0"
12"
Bed of Stream
20'0"
8'0"
ELEVATION
3'0"
8'0"
Fill over culvert to be at least 3" in center
Bars 12" C to C
END VIEW
Bars 8" C to C Every 3rd bar turned up others down
Bars 3'0" C to C
-20'0"-
Concrete for top 1-2-4
All other concrete 1-3½-5
Embed all reinforcing 2" from face of Concrete
CROSS SECTION
Carry footings to solid foundation and tamp earth carefully around them
If in poor foundation piling is necessary
Apron Wall
PLAN
Engr. Contr.

Fig. 3—Standard Span for 20-Ft. Reinforced Concrete Culvert.

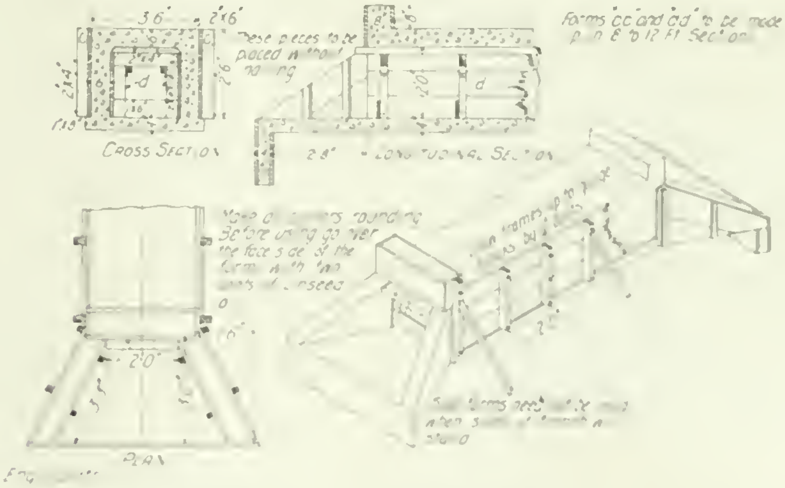

3'6"
2'6"
These pieces to be placed without nailing
Forms cc and dd to be made in 8 to 12 Ft. Sections
CROSS SECTION
LONGITUDINAL SECTION
2'0"
PLAN

Fig. 4. Forms for 2x2 Ft. Concrete Culvert.

Unclassified and General Articles

Note: This section is devoted to methods and cost articles on construction work not properly coming under any of the preceding classifications.

Answers to Engineering and Contracting Questions.

Sirs: We have a soft sand rock containing very hard quartz pebbles. The material is wet and several machines have worn so fast that it has not been economical to crush. We have the advantage of gravity for the plant, the location being on a hillside. We propose to put in storage bins, crushing, screening and conveying machinery. Our problem is to get a crusher that will handle the stone properly and economically. Any information will be thankfully received.

We should be glad to have any of our readers, having knowledge of or experience in crushing soft, wet sand rock containing hard pebbles, give us their advice —Editors.

Sirs: What objections are there to limestone as an aggregate for concrete. The writer is operating in a limestone country and has been told that there are objections to it for concrete aggregate. The limestone available is a hard crystalline stone and breaks in good shape for concrete.

Some constructors object to limestone concrete for fire-proof building work since it calcines at high temperature and thus is more readily damaged by fire. It has also been found that waters carrying carbonic acid gas will pit the inside of a conduit by dissolving the pieces of limestone in the concrete. Such a case of pitting so severe as to require relining the conduit was described in ENGINEERING-CONTRACTING for September 11, 1907. Limestone makes a strong, sound concrete and in general is regarded as one of the best of concrete aggregates.—Editors.

Sirs: What proportions are necessary to make a concrete wall 1 ft. thick waterproof? Can it be made so by plastering the inside face with a 1-2 mortar?

Categorical answers to these questions are impossible. Concrete is water-proof in proportion to its density. A rich concrete is more dense than a lean concrete, hence a concrete rich in cement is more nearly impervious to water than one poor in cement other things being equal. A concrete made of graded aggregates is more dense than one made of aggregates of uniform size of particles, hence a graded concrete is more impervious than one made of an aggregate of nearly uniform size. Also a graded concrete lean in cement may be more impervious than an ungraded concrete rich in cement. Perhaps the most familiar rule for grading concrete aggregates to secure water-tightness is that of Mr. W. B. Fuller, which will be found explained in detail in "Concrete, Plain and Reinforced," by Taylor and Thompson, and briefly in ENGINEERING-CONTRACTING, February 10, 1909, p. 106. In brief, the imperviousness of concrete depends on its density and density depends upon various factors besides the proportions of cement, sand and aggregates. A plastering of 1—2 mortar will certainly help to make a wall water-tight, if the plaster sticks. Plastering a concrete surface so that the plaster will stick must be done by special methods and with care; a method claimed to be satisfactory is described in ENGINEERING-CONTRACTING, February 10, 1909, p. 111. Since the difficulty of plastering on concrete is to make the plaster stick, this difficulty is naturally increased by water pressure against the joint, and so when plastering is resorted to to secure water-tightness the plaster is placed on the side of the wall against which the water presses, for example the outside of a cellar wall or the inside of a tank.—Editors.

Sirs: In constructing a concrete arch park bridge a considerable amount of ornamental work is called for—keystones, rosettes, dentils, cornice, balustrade, etc. What is the best practice in constructing such ornaments?

Generally speaking, the best procedure is to mold or cast the ornaments separately, not trying to form them in one piece with the spandrel walls or arch ring. Keystones and rosettes, which are surrounded by mass concrete, are so molded and then braced in position just before the concreting reaches the places where they are to be located and the mass concrete is deposited around them. The ornament itself is molded on a block, the body of which extends back into the mass concrete to bond it firmly in place. Cornice blocks, balusters, base blocks, railing blocks, etc., are set in place after being molded just as similar forms of cut stone would be set. The method of molding the ornament will be determined by its character. Simple patterns may be molded in wooden forms made by a pattern maker, or metal forms can be ordered from one of the various concerns who make them. Elaborate or intricate patterns or those calling for some special surface texture or finish require plaster of paris, glue, sand or other special molds and skilled manipulation, and such castings had better be contracted for with some good art concrete works. For forming plain panels, beads, coves, etc., the only practicable method is to provide the necessary patterns in the main arch and wall forms. Often the cornice course is provided for in the regular forms. Examples of molds and forms for ornamental work and the processes employed are given in "Concrete Construction—Methods and Costs," by Gillette and Hill. Editors.

Sirs: I am after information in regard to wood or paper "fiber." I believe that the above is the commercial name for it. What I have reference to is a dark red substance which is used quite extensively around electric light plants for wearing surfaces and for insulating. What I want to know is: the size that I can get this substance in? Can it be manufactured in blocks 13 or 14 ins. in diameter? If not, whether it could be built up in layers and cemented together, and make that size block, and if it would resist heavy pounding?

The following answer to our correspondent has been obtained from one of the largest manufacturers of the product, the Delaware Hard Fiber Co., Wilmington, Del. "Hard fiber is not a wood pulp product, but is a pure cotton product. It is used extensively for friction purposes and for electrical insulation. It is made in sheets, rods and tubes; sheets measure about 4 ft. by 6 ft., thickness from 1/64 in. up to 1¾ ins. It is not practicable to cement sheets of this material together to make thick blocks, as there is no cement that will hold it; however, thin sheets of it are glued to wood in manufacturing trunks. It stands a tremendous amount of pounding and wear and takes an enormous pressure to crush it. It was used to insulate the Trinity building, New York, a 20-story office building, by covering the piers with sheet fiber ⅝ in. thick. The constructor made some elaborate tests to ascertain the strain before erecting the building on top of these sheets of fiber and reported the results of his tests as follows: A piece of fiber ¾ in. thick, 3x3 ins. compressed 1/32 in. under 90,000 lbs. pressure. A piece of fiber ¾x1x1 in crushed under 34,700 lbs. pressure. Fiber absorbs water and thus makes excellent gaskets and bibbcock washers for plumbers' use; it does not absorb oil, hence it makes excellent gear wheels, used extensively by automobile manufacturers."—Editors.

Sirs: To what extent does the addition of coloring matter to cement to produce a tinted surface injure the mortar or concrete? What is the best method of adding the coloring matter? Is there any other successful method except by using colors to produce tinted concrete?

Practically all coloring matters injure the mortar, but the injury is negligible in case of small additions for all but a few substances. Safe practice in the selection of coloring matters and in the amounts to be added are given in Reid's "Concrete and Reinforced Concrete Construction," and in other treatises on concrete. The preferable method is to add the dry color, powdered, to the dry cement, mixing the two well in a cylinder or box rotating on trunnions. The more usual practice is to add the color to the mixing water. The other method of securing tinted concrete is to use sand and aggregate of colored stone. These give a natural and durable color and few artificial coloring matters give either. Useful hints on coloring concrete are to be found in the catalogues of the manufacturers of concrete block machines.—Editors.

The first of the postal automobiles at Bagdad went into service recently. The car carried the mail, hitherto borne on camels' backs, from Aleppo, a distance of 625 miles, in 60 hours. When it is remembered that the roads are rough camel tracks leading through the deep sands of the Syrian desert and the stony plains of Mesopotamia the journey at the rate of little more than ten miles an hour appears quite a creditable performance.

An Act Fixing the Legal Status of Land Surveyors and Those Engaged in Certain Branches of Civil Engineering in Idaho.

SECTION 1 All persons hereafter desiring to engage in land surveying, topographic engineering, hydraulic and hydrographic engineering, construction and designing engineering or administrative irrigation engineering must, before engaging in such work, satisfy a board to be known as the Board of Examining Engineers, who shall consist of the State Engineer and two other civil engineers of thorough training and experience to be appointed by the Governor and to serve without compensation, that they are competent and capable of performing the class of work in which they desire to engage.

SEC 2 The Board of Examining Engineers may adopt all rules and regulations necessary to the proper carrying out of the provisions of this Act and after satisfying itself by conducting examinations or by investigations of the record, training and experience of those who may desire to qualify, shall grant licenses as hereinafter provided

SEC 3. Where in the opinion of the Board of Examining Engineers it is necessary to examine the applicant, written questions shall be submitted, which shall be answered in writing The examination to be given by the Board shall cover the following subjects, according to the class of license sought by the applicant Applicants for license of the first class shall be examined as to their knowledge of plane and topographic surveying, hydraulics, computation of earth work, designing of irrigation works and structures, construction work and irrigation law and practice Applicants for license of the second class shall be examined as to their knowledge of plane and topographic surveying, hydraulics, computation of earth work and designing of irrigation works and structures Applicants for license of the third class shall be examined as to their knowledge of plane and topographic surveying, and hydraulics Applicants for license on the fourth class shall be examined as to their knowledge of plane and topographic surveying Applicants for license of the fifth class shall be examined as to their knowledge of plane surveying

SEC 4 Persons holding licenses granted under the provisions of this Act shall be ranked in the following classes A license of the first class shall entitle the licensee to perform all engineering work in connection with irrigation enterprises and all work generally engaged in by civil engineers in the practice of their profession A license of the second class shall entitle the licensee to perform construction and designing engineering work A license of the third class shall entitle the licensee to perform hydraulic and hydrographic engineering A license of the fourth class shall entitle the licensee to perform topographic engineering A license of the fifth class shall entitle the licensee to practice land surveying The holder of a license of any class shall also be deemed to be the holder of a license in each inferior class herein provided

SEC 5 Before obtaining license applicants shall file with the Board of Examiners an official bond in the sum of $500 running to the State of Idaho, conditioned upon the faithful performance of all work to be done under and by virtue of the license applied for, together with the official oath properly subscribed and shall pay a license fee of $5.00 A licensee under one class desiring to obtain license under another class may do so by passing the required examination and by paying an additional fee of $1.00.

SEC 6 All persons at the time this Act shall become effective, holding a land surveyor's license under the provisions of Sections 1101, 1102, 1103, 1104, 1105, 1106, 1107, 1108, 1109, 1110, Political Code, Revised Codes of Idaho, shall be considered as holding a license of the fifth class hereinbefore provided for.

SEC 7 Licenses issued in accordance with this Act shall remain in force until revoked for cause as hereinafter provided

SEC 8 Upon failure of any licensee under this Act to keep his official bond in full force and effect or to comply with the requirements of this Act or to furnish substantial proof of such compliance, the State Engineer must revoke his license and no license shall be issued to him within one year from such revocation

SEC. 9. All papers received by the State Engineer on application for license shall be kept on file in his office and a proper index and record thereof shall be kept by him and he shall keep a list of all licenses under thic Act

SEC. 10 Every licensee under this Act is hereby authorized to make surveys relative to the sale or subdivisions of land and retracing or establishing all property or boundary lines public roads, streets, alleys or trails; and it shall be the duty of any licensee under this Act whenever making any such surveys except those relative to the retracing or subdivision of cemetery or town lots, whether the survey be made for private persons, corporations, cities or counties, to set permanent and reliable monuments, and such monuments must be set and marked according to instructions contained in the manual issued by the Department of the Interior with the additional characters "L. S." On the completion of any survey as in this Section provided the licensee performing such survey shall file with the County Surveyor of the County in which such survey has been made, a full and complete copy of all field notes made in connection with such survey

SEC 11 Any person not a licensee under this Act who shall set any monument for the purpose of establishing an old or lost corner of any public survey shall be guilty of a misdemeanor and upon conviction thereof shall be punished by a fine not exceeding fifty dollars or by imprisonment in the County Jail not exceeding [illegible] days or by both such fine and imprisonment

SEC 12 Every licensee under this Act is authorized to take testimony to identify or establish old or lost corners, or to perpetuate a corner that is in a perishable condition or whenever the importance of the survey makes it desirable, and to administer oaths to assistants for the faithful performance of duty A record of such oaths shall be kept as part of the field notes of the survey

SEC 13 After June 1 1909, no work required by statute to be done by a surveyor or by an engineer, meaning one engaged in the practice of civil engineering shall be legally valid unless performed or directed by a licensee under this Act, holding a license of the proper class, permitting him to perform the class of work, the legal validity of which it is desired to establish

SEC 14 Sections 1101, 1102, 1103, 1104, 1105, 1106, 1107, 1108, 1109, 1410, Political Code of the Revised Codes of Idaho, are hereby repealed.

A New Derrick or Cableway Skip.

We illustrate herewith a new cableway or derrick skip invented by Willard O Lockwood of Schenectady, N Y The two distinguishing features of this skip are the bail to lift it and the automatic door to make the skip a closed box Some of the advantages claimed for this skip are that owing to the use of the bail, time is saved in picking up the skip as there is one less hook to connect and the bail is in position to be connected at once Owing to the door, rocks and material cannot fall out of the skip, thus interfering with the men

Skip with Automatic Door.

working under it and causing some of them to be injured.

In loading large boulders into the skip the bail is swung back, causing the door to open wide, thus allowing the boulder to be rolled onto the pan by hand. In case of loading with a steam shovel, chains are used to support the door, so the bail can be swung to the point, leaving a wide open skip, but closed on all sides.

This skip has been used on the New York State Barge canal on a Lidgerwood cableway costing about $8,000. It is stated that the capacity of the cableway was doubled by the use of this skip, without increasing the payroll one cent. The skip is dumped automatically by the hoisting engineer.

The skip is manufactured by the Cockburn Barrow and Machine Co., 30 Church street, New York City.

LETTERS TO THE EDITORS.

The Economy of Contract Work Compared with Day Labor Work.

Sirs: I have been much interested in the many useful and instructive articles in Engineering-Contracting and in the discussions by the editor. However, I have been a little confused by the stand he takes on contract work vs. day work. I have been a civil engineer for over 25 years. Three years of that time I was a member of a contracting firm. I have built a good many miles of railroad and done many sorts of work by both contract and the day labor systems. I have advised my employer on three occasions to do work by day labor, and believe it was to his interest to do it that way. As contractors, we had some work in Wyoming which we had offered subs our full price to do, and no one would attempt it. I took the forces of three subs, put them at work on a day rate, made the foreman look to me for orders, and in the end made a good profit on the job. I have done three jobs by force account for the railroads employing me, and the work in each case cost less than contractors asked for doing the work.

A contractor will pay me $50 or $60 per week, straight time, while he can employ foremen for $2.50 per day. Does he not think me worth more than the foreman? Why should I not handle my work more economically. In the Journal of the Association of Engineering Societies about 20 years ago will be found an account of some work done by force account at St. Louis which cost far less than the lowest bid a contractor would make. Also, the rebuilding of the chimney of a power house destroyed by the St. Louis cyclone, described by Col. E. D. Mier in the same journal in 1896-7, shows a similar result.

Is it not the engineers of the land who have cheapened the methods of construction and bettered the ways of handling material along our railroads?

I am vain enough to believe that I can take a contractor's force and increase his output over his $2.50 foreman. I can take his force and move more material than he does, unless it be a job where they are engaged in killing off their mules. I cannot take their outfit and do more work. I cannot work such an outfit at all.

Perhaps I fail to get the drift of your arguments. My experience as an engineer, and as a contractor, leads me to think that where bidding is unrestricted and work let to the lowest bidder, that nothing but evil and trouble results. I have in mind a case where a contract was let to a man for a freight house to cost $17,800. The other bidders clustered about $20,000, and the house was delayed five months beyond the time of completion, the superintendent was kept on the work this length of time, the estimates were tied up, the company was out of the use of the building and work was not so well done as would have been by others, and in the end several compromises were made in order to get the building at all. Yours truly,

Railway Engineer.

[There is no doubt whatever that civil engineers frequently make excellent superintendents of construction work. Indeed, that is one of the lines of occupation into which many engineers have been going and will continue to go. The point that we have been urging is not that engineers are incapable of managing work economically, but that no man, engineer or what not, can get other men to do their best when those other men know that their pay is coming directly from the rich government or the rich railway company. This obstinate resistance to doing a good day's work for the government ultimately breaks down the strongest determination on the part of the engineer or manager who is superintending the construction in behalf of the government. He may start out with the best of intentions, but invariably he finds himself yielding to the inertia of laziness that opposes him, if the work lasts long enough to be a true test of efficiency. Railway companies have learned this lesson, and they rarely do construction work with "company forces." When they do attempt it on any large scale their records prove the folly of the attempt. The writer has not one but hundreds of such records of actual cost of "company force" work, covering construction on ten different railways, and his conclusions are therefore based upon no mere theory.—Editor.]

An Adding and Subtracting Scale.

We illustrate on this page an adding and substracting scale for fractions that will no doubt be found useful to engineers and contractors. It is made of celluloid, printed in plain figures and will fit in the vest pocket. To use it is very simple, and the results are shown in fractions and their decimal equivalents. The inner disc revolves on the outer one and the cut on the inner disc shows the results. Fractions of one inch can also be transposed into decimals by this scale. Mistakes will be avoided by the use of this scale. The inventor is E. F. Chandler, but the scale is sold by J. S. Barron, Barron Bldg., New York city. The price is $1.

Adding and Subtracting Scale for Fractions.

According to the Statistical Abstract for 1908, issued by the London (England) County Council, the ratable value of London is $221,000,000 and the number of rated houses 632,591. The amount of loans outstanding on the credit of the rates was in 1907 $542,700,000. In 1900 the total was $221,300,000. Other figures for 1908 are:

Parliamentary electors..........	666,833
County Council electors........	816,593
Children at elementary schools..	726,538
L. C. C. tramway receipts......	$8,350,000
Letters delivered...............	771,200,000
Post cards delivered............	191,600,000

In 1907 there were 8,774 acres of agricultural land in the county of London, including 272 acres of corn. The number of cattle was 4,227, of sheep 3,374, and of pigs 2,038.

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The Value of Deposits of Cement Materials.

One of the questions often asked the editor of engineering and cement trade papers runs something as follows: "I own a tract of land on which there is a large deposit of marl and clay which I am told is suitable for the manufacture of cement. What is the value of such a deposit and can you refer me to persons who are in a position to develop it?" Sometimes it is a deposit of "cement rock" or of limestone and shale that has been discovered, but the underlying idea of the query is always the same. It is that there is great intrinsic value in a deposit of materials from which cement can be made. The error of this idea would be of small consequence had it not been seized upon by promoters as an opportunity to finance cement manufacturing companies of doubtful value. This has been done to the detriment of legitimate enterprises and to the loss of honest investors, and it deserves comment.

There is small intrinsic value in a deposit of materials from which cement can be made. Such materials are very common and are widely distributed. They can be purchased in hundreds of places for from five to fifty dollars an acre. The financial success of a cement works depends on other things than the availability of suitable raw materials. There are plenty of them north, south, east and west, and they can be bought cheaply—for a song in many localities. It is not, therefore, physical availability, but commercial availability that makes a deposit of cement materials possible for cement manufacture. We will try briefly to demonstrate this fact.

Considering first the physical and chemical character of the raw materials, it takes only a few small differences, either chemically or physically, to make one deposit a good cement material and another deposit a poor cement material. Cement can be made from both, but cement can be made so much cheaper from one than it can be made from the other that the last cannot compete commercially with the first, other things being equal. A small increase in the moisture content, a little greater hardness, slightly more irregularity of composition, a small over-content of alumina or magnesia, a half-dozen other differences will rule one deposit out of consideration as compared with another deposit. A manufacturer must not only be able to make cement from his raw materials, but he must be able to make it as cheaply as any other manufacturer operating under the same market conditions. Because of this fact the almost infinite number of raw materials from which cement can be made is reduced by commercial conditions to a very few in actual practice.

Now let us go another step. A cheap, suitable fuel is almost as important for the commercial production of cement as is a suitable deposit of raw materials. It takes about 200 lbs. of coal to make a barrel of cement, and a good power coal is required, so that many coals and particularly many western coals are not suitable. A deposit of cement materials to be commercially available for cement manufacture must be able to command a regular supply of good fuel at a reasonable price. In some of the eastern cement regions such coal can be laid down at the mill for $1.50 a ton. This is an unusual figure, but it is given to show what competition has to be met in some sections.

Assuming that the particular deposit of cement materials meets the requirements of quality and of cheap fuel supply, the next question is, can the cement be got to the market. Cement is a bulky product and it is a cheap product, and it will not stand heavy transportation charges. But more than this, transportation must be available to the leading markets. Local markets seldom warrant a large cement mill, the big outside markets must be reached and as these are competitive markets they must be reached at a cost as low as they can be by the nearest competing mill. If there is only one line of railway to this market the new mill is at a disadvantage, compared with the competing mill which has a choice of two lines. The competing mill can get cheaper rates and better service. It counts very little how cheaply cement can be made if it cannot be got to the market cheaply enough to enable its profitable sale at competitive market prices.

In the foregoing we have barely touched on some of the considerations which have to be taken into account by the owner of a deposit of "cement materials" who has been led to consider the development of the deposit. They should be sufficient to show that many things lie between a bed of marl and clay or an outcrop of cement rock and a marketable Portland cement. In conclusion, we will quote the words of a high authority on the promises of success in cement manufacture.*

"On going over a long series of records concerning cement companies which have been organized during the past five years, certain ratios of success seem to be fairly well established. These may be summarized as follows:

"1. Of one hundred cement companies taking out charters, over half will fail to sell sufficient stock to even commence actual construction. In these cases the stock purchaser may receive back some of his money.

"2. Of the plants which begin construction, about half are unable to complete it without reorganization and new security issues.

"3. About 25 per cent of the plants which actually get to the operating stage default on their bond issues at some time during the first five years of their history, or are prevented from such default only by the issue of secured notes or other securities paid for by the stockholders.

"4. Of each hundred companies organized, not over five will ever pay dividends to the original stockholders sufficient to make a fair interest return on the investment."

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*The Portland Cement Industry from a Financial Standpoint. by E. C. Eckel.

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Concrete and Reinforced Concrete Section

Note:—This section is devoted to methods and cost of constructing concrete and reinforced concrete structures. It will cover the selection, testing and proportioning of concrete materials; laboratory tests of concrete; concrete mixing, transportation and placing; fabrication and placing of reinforcement, and form construction and erection. It will also contain articles on new and interesting developments in the design of reinforced concrete.

A Comparison of Costs of Concrete Buildings in Terms of Square Foot of Floor and Cubic Foot of Enclosed Space.

A common method of stating the cost of buildings for approximate estimates and comparisons is in terms of dollars per square foot of floor or cents per cubic foot of space inclosed. Either unit has been supposed to be reliable one for approximate comparisons and both have been used frequently to prove in individual cases the economy or the high cost of construction work. In view of these facts the following comparisons made by Mr. Leonard C. Wason, president, Aberthaw Construction Co., Boston, Mass., will he of decided interest. In preparation for a study of the figures given it is important to note that Mr. Wason's conclusions are that, after making this comparison he is convinced that neither method is accurate enough to put much reliance on, but that the square foot method is a little safer than the other.

The comparative figures compiled by Mr. Wason are given in Tahles I. to IV. inclusive. In each case the total cost includes masonry and carpentry work without interior finish or decorating, plumbing and heating. The effort has been made to put the buildings upon a comparative basis as regards the amount of work done on each.

The first table consists of the total cost of actual contracts executed. The second table consists of bona fide bids on complete buildings on which Mr. Wason's company were not the lowest bidders, but where the difference was not as a rule very great. The third and fourth tables are bona fide bids on work by another contractor whose experience was similar to that of Mr. Wason's. As a rule, cubic foot measurements are given in cents only, seldom being carried to any closer sub-division. In reference to Table IV. on second class buildings, it will be noted that for the largest building a variation of 1 ct. per cu. ft., amounts to over $28,000, while the smallest one in the list amounts to only a little over $5,400. Again, on the last three items, the cubic foot price is practically identical, while the square foot measurements corresponding vary by more than 100 per cent, with no easily apparent reason in the design.

In Table III. another discrepancy is noticed. In the first and the last items, the highest and the lowest per cubic foot, as well as per square foot are on office buildings of similar type which were within one mile of each other where there is no apparent reason for such discrepancy in the design or difficulty of access in the erection of the building.

TABLE I.—COST OF FIREPROOF COMPLETED CONTRACTS.

Kind of building.	Joh cost.	Volume in cu. ft.	Floor area in sq. ft.	Unit cost per cu. ft.	Unit cost per sq. ft.
Offices and stores	$181,194	1,365,830	90,474	$0.133	$2.00
do.	61,646	496,780	39,840	.124	1.545
Factory	12,774	112,440	7,519	.114	1.70
do	44,652	746,674	49,546	.060	.902
do	39,830	312,000	24,960	.127	1.60
Garage	10,436	156,198	10,806	.085	1.23
Filter	19,993	149,250	19,208	.134	1.04
Fire station	6,757	44,265	2,982	.153	2.26
Observatory	3,625	9,734	657	.373	5.45
Filter	20,076	59,991	5,243	.333	3.82
Highest	......	....	......	.333	3.82
Lowest	....	....	.....	.06	.90
Average	......	....	......	.138	1.72

TABLE II.—COST OF FIREPROOF COMPLETE BUILDINGS.

Kind of building.	Job cost.	Volume in cu. ft.	Floor area in sq. ft.	Unit cost per cu. ft.	Unit cost per sq. ft.
Storehouse	$141,755	1,714,448	168,696	$0.0827	$0.84
Hospital	60,800	703,692	57,654	.0865	1.05
Office building	61,646	496,780	39,840	.124	1.545
Cold storage	200,051	1,535,000	154,000	.13	1.30
Factory	19,292	212,400	15,000	.091	1.28
do	141,529	1,327,868	106,022	.107	1.335
Storehouse	76,796	1,140,000	146,000	.0685	.575
Mfg. building	91,377	1,380,500	90,240	.067	1.01
Office	136,880	693,840	56,552	.197	2.42
Factory	13,064	105,600	8,800	.124	1.485
do	75,604	1,211,364	74,604	.0625	1.01
do	23,332	180,000	16,394	.129	1.42
Highest	....	....	....	.197	2.42
Lowest	....	....	......	.0625	.575
Average	....	....	......	.1088	1.27

TABLE III.—COST OF FIREPROOF BUILDINGS.

Kind of building.	Cost.	Volume in cu. ft.	Floor area in sq. ft.	Unit Cost per cu. ft.	Unit Cost per sq. ft.
Office building	$ 70,690	441,000	35,854	$0.159	$1.97
Cold storage	132,365	1,016,400	101,640	.13	1.30
Hospital	44,451	348,320	34,832	.127	1.27
Hospital	51,574	414,732	29,838	.124	1.73
Bank	65,580	533,750	....	.123	....
Masonic	180,197	1,479,456	....	.122	....
Warehouse	31,280	259,700	24,500	.120	1.28
Garage	59,105	497,420	....	.118	....
Warehouse	275,723	2,597,000	212,000	.106	1.30
Hotel	220,646	2,116,106	....	.104	....
Hospital	49,724	485,789	38,247	.100	1.30
Office	25,151	264,687	....	.095	....
Cold storage	82,711	909,240	66,745	.091	1.24
Club	43,586	513,808	....	.085	....
Office	60,003	501,575	67,400	.084	1.12
Highest				.159	1.97
Lowest				.084	1.12
Average				.113	1.39
Per cent variation, high and low				53.8%	57.0%

TABLE IV.—COST OF MILL CONSTRUCTION OR SECOND-CLASS BUILDING.

Kind of building.	Cost.	Volume in cu. ft.	Floor area in sq. ft.	Unit Cost per cu. ft.	Unit Cost per sq. ft.
Mill	$ 66,516	544,788	44,172	$0.122	$1.51
Warehouse	337,000	2,808,850	....	.12	....
Mill	113,288	1,271,300	129,920	.0891	.875
Storehouse	101,098	1,714,448	168,696	.059	.60
Mill	90,703	1,622,128	152,200	.056	.60
Mill	72,048	1,331,200	83,200	.054	.865
Mill	85,754	1,752,609	81,500	.048	1.05
Mill	122,128	2,641,000	98,059	.046	1.25
Mill	94,341	2,036,731	174,000	.046	.542
Mill	129,405	2,867,535	157,730	.045	.82
Highest				.122	1.51
Lowest				.045	.542
Average				.069	.90

The Ministry of Ways and Communication of Russia has under consideration the extension of several railways during the year 1909, and to that end proposes an expenditure of $30,250,000, partly as follows: The Amur Railway, $7,650,000; reconstruction of the hilly part of the Siberian Railway, $5,600,000, and for a second track of the same, $6,630,000; completion of the Ekaterinburg-Perm line, $2,900,000; for the construction of a new bridge across the Volga, near Yaroslav, $515,000, etc.

Method and Cost of Constructing a Concrete Core Wall for Wing Dam.

This article covers the construction of 2,181 ft of core wall, being a portion of a wall which will ultimately be $2\frac{1}{4}$ miles long. This wall was built along the toe on the pool sides of a rock-fill dam in a trench excavated to solid rock. The face of the wall has a batter of $3\frac{1}{2}$ in 12 and the back conforms to the face of the side of the trench below water and is practically vertical above water, being 2 ft wide on top. Level with the top a 6 in concrete apron extends back 20 ft over the top of the rock-fill dam. The wall varies in height from 10 to 21 ft. It was built of 1-5 gravel concrete and is reinforced as follows: A longitudinal line of old steel bars was placed in the center of the wall 6 ins. below the top. Over this horizontal bar were hooked vertical bars spaced 5 ft apart. This reinforcement was used principally to anchor down any pieces of the wall top which might break away.

Forms.—As fast as the dipper dredge opened the footing trench to rock, 2-in holes 10 ft. apart were drilled into the ledge. Uprights of 6x8 in. timbers having 2-in rods 5 ft. long bolted to the bottoms were erected by inserting the rods in the drilled holes and bracing the tops back to posts set into the rock-fill dam. The uprights were set to the inclination of the face of the wall. Waling pieces, 6x6 ins.x16 ft. were connected several end to end by bevel joints, with one bolt in each so the joint would be flexible. The several lengths of waling pieces were thus connected inside the uprights. A vertical plank was then bolted to the waling near a joint and by it the joint was pushed down under water 3 ft. and a second waling was bolted to the plank at the surface of the water. Other planks were then bolted to the first waling at the joints on each side of the joint first sunk and these joints were in turn pushed down 3 ft., permitting the second waling to be bolted to the planks. In this manner one waling after another was added at 3-ft. intervals until the first waling had been pushed down to rock. The walings were not fastened to the uprights as the up-thrust of the water pushing them against the slant of the uprights held them fast.

The lagging consisted of vertical 2x12 in. planks, set close inside the walings; these planks were nailed to the top-most waling, but were not fastened to the lower walings.

The forms were built around curves without alterations as the one-bolt waling joints gave considerable flexibility. Ordinarily, the wall was concreted in alternate 30 to 50 ft sections. The forms were built continuously in advance and torn down behind as fast as the concrete set. At the ends of sections of wall, transverse bulkheads were built inside the form and bonding recess forms fastened to them. To remove the forms the braces from the tops of the uprights were unbolted and the whole form was pushed away from the wall and taken apart. As the forms were not nailed, except at one point, as noted above, the lumber was but little damaged and with the addition of a small amount of lagging there is enough lumber remaining from the form-work for the first 2,181 ft of wall to build the remainder of the wall. The form lumber was used from three to four times on the portion of the wall that is now completed.

Concreting.—The concrete mixing and handling plant was mounted on an $18\frac{1}{2}$x100 ft barge. On one end of the barge was a $\frac{3}{4}$ cu. yd. Chicago concrete mixer with a gravel supply bin mounted overhead. On the opposite end of the barge a stiff-leg derrick, operated by a bull wheel was erected. This derrick handled the gravel from stock barges moored alongside to the supply bin over the mixer, and also handled the concrete from the mixer into the forms. A wooden bottom dump bucket was used to deposit the concrete under water and did the work successfully up to a depth of 17 ft.

Wages and Cost.—The gangs worked consisted for forms of 2 carpenters and from 2 to 6 helpers and a drill boat crew setting uprights, and for concreting of usually 14 men, including foreman, derrickman, mixerman, etc. The wages paid were as follows:

Drillmen, per month	$60
Foreman, per month	$75
Overseer, per month	$125
Carpenters, per day	$2.50
Laborers, per day	$1 to $1.25

All men were subsisted in addition to regular wages, which was considered equivalent to 50 cts. per day per man additional. The prices of materials were as follows:

Coal, per ton	$2.20
Corrugated bars	$2.85
Round bars	$1.80
Cement, per bbl., f. o. b. Moline	$1.11
Gravel, per cu. yd. on barge, towing extra	$0.65
Lumber, per M. ft., B. M.	$26.50

The cost of the work was as follows:

Item	Total	Per cu. yd.
Preliminary expense	$ 9,074.30	$2.0441
Supt. and office	1,798.30	0.4051
Excavation	467.50	0.1053
Totals	$11,340.10	$2.5545
Concrete work:		
Forms:		
Materials	$ 2,375.30	$0.5351
Labor	940.06	0.2117
Drilling	168.10	0.0379
Coal for drills	94.57	0.0213
Totals	$ 3,578.03	0.8060
Concrete materials:		
Cement	$ 7,059.18	$1.5901
Cement handling	169.11	0.0381
Cement testing	130.92	0.0295
Gravel	2,847.85	0.6415
Reinforcement	104.08	0.0235
Towing	945.78	0.2131
Towing, coal for	378.28	0.0852
Totals	$11,635.20	$2.6210
Mixing and placing concrete:		
Labor	$ 2,054.60	$0.4628
Coal	283.71	0.0639
Totals	$ 2,338.31	0.5267
Back filling	$ 203.61	$0.0459
Subsistence	1,327.32	0.2990
Plant repairs	298.69	0.0673
Totals	$ 1,829.62	$0.4123
Grand Total (4,439.1 cu. yds.)	$30,721.32	$6.9205

Regarding these items it needs to be noted that the $9,074.30 for preliminary expenses includes a large number of miscellaneous items, including new machinery, erection of plant, etc., charged out in full. To compare the work with a contract job the engineer suggests taking this item at about $5,000, which represents about a 20 per cent depreciation charge on all plant used. It should be noted also that all form lumber is charged in full against this 2,178 ft. of wall, yet, as stated above, it is enough to build the remainder of the wall and should ultimately be charged against the total yardage. In the same way most of the items constituting preliminary charges must be distributed over a large yardage in addition to that of the wall already built.

The wall was built by day labor, under the direction of J. B. Bassett, M. Am. Soc. C. E., U. S. Assistant Engineer, Rock Island, Ill. We are indebted to Mr. Bassett for the data from which this analysis of costs has been prepared. The data was a portion of the Mississippi improvement work at Moline, Ill.

On Feb. 17 14 shovels in the Empire District, Central Division of the Isthmian Canal, excavated 22,286 cu. yds. of material in a working day of eight hours, an average of 1,592 cu. yds. per shovel for the day, states the Canal Record. The shovels were under steam a total of 112 hours and were actually digging 79 hours and 30 minutes. The time not spent in digging is accounted for as follows: Cleaning track, 1 hour and 25 minutes, waiting for cars, 23 hours and 10 minutes, moving, 1 hour and 55 minutes, cleaning dipper, 1 hour and 15 minutes; repairing shovel, 3 hours and 25 minutes, coaling shovel, 30 minutes; sluing, 20 minutes. On Feb. 18, seven shovels in the Labernilla Construction District, Central Division, during eight working hours, excavated 11,450 cu. yds. of material, an average of 1,636 cu. yds. per shovel for the day. The shovels were under steam 56 shovel hours and were actually digging 48 hours and 5 minutes of this time.

The Stress Sheets and Some Construction Details of a 280-ft. Span Rubble Concrete Arch Bridge at Cleveland, O.

The longest span concrete arch to be actually placed under construction in the United States is the 280-ft. arch bridge now being built over the gorge of Rocky River on the outskirts of Cleveland, O. The bridge is a county structure for highway and street car service. It occupies a commanding position in what is coming to be a fine residence district and attractiveness of appearance is of importance. It was on this last account that an arch structure of concrete was chosen.

The choice of a single arch span flanked by arched approaches instead of a two or three span structure was determined by practical considerations. The ice floes which come down the river in spring are dangerous; a design requiring piers in the river invited danger and one calling for a clear span from bank to bank avoided danger. On this count alone a single span bridge was preferable. The next consideration was that of comparative cost and careful preliminary plans and estimates made for a three-span bridge showed conclusively that its cost would be approximately the same as that of a single span bridge. The evidence seemed conclusively to favor the single span design and it was therefore chosen.

The design finally worked out is shown by Fig. 1. A single arch between heavy abutment piers 280 ft. apart spans the stream and carries a roadway on spandrel arches. This roadway is continued on each side by arch viaduct approaches. It is 40 ft. wide and there is an 8-ft. sidewalk on each side. The other dimensions are given in the drawing, Fig. 1. The main arch consists of two parallel ribs, each 22 ft. wide and 11 ft. thick at springing lines and 18 ft. wide and 6 ft. thick at the crown. The space between ribs at the crown is 16 ft.

This same parallel twin construction is carried all through the main arch span and piers. The piers are made in two halves connected only by a curtain wall; each half-pier is made hollow to save material. For 50 ft. each side of the crown the spandrel space over each main arch rib is filled by two parallel solid spandrel walls one on each side of the rib. The spandrel arches which continue these walls are each composed of two parallel piers and ribs connected by curtain walls. The space between the two sets of spandrel walls and arches over the main arch ribs is spanned by a reinforced concrete slab and girder platform. The approach arch construction is similar to that of the spandrel arches, viz., four ribs built in piers with a solid pier carrying each pier and curtain walls and slabs connecting the two piers. The slabs joining the roadway platform, those connecting spandrel arch rings and the rings of the approach arches are reinforced, but all the other parts in-

Loading of Arch Rib.														For Dead Load Stresses													For Dead Load + Live Load Stresses.								
Divisions of Ring	Depth of Ring.	Width of Ring.	Weight of Rib in lbs.	Horizontal Div. of Rib	Floor Load @ 9000 lbs. per ft.	Spandrel Walls, Arches & Piers.	Subway Floor.	Total D. L. per Rib in Kips.	Summation.	L. L. per Horizontal Div. of Rib	Summation in Kips.	Summation for D. L. + L. L. in Kips.	Summation for Arch Rib, SpandrelWalls & Piers	Divisions of Arch Ring	y-Ordinates	y^2	k-Ordinates	z-Ordinates	m-Ordinates	my	a-Ordinates	Eccentricity.	Moment, ft.-lbs.	Direct Stress	Eccentric Stress	Direct Stress + Eccentric Stress	z-Ordinates	m-Ordinates	my	a-Ordinates	Eccentricity	Moment, ft.-lbs.	Direct Stress.	Eccentric Stress.	Direct Stress + Eccentric Stress
P_1	5.00	18.06	89,700	5.2	46,800	11,200	6,100	153.8	153.8	22.4	22.4	176.2	100.9	S_0	*36.835	†2685.84	+15.65	*41.00	+17.61	+ 648.93	+15.58	−0.07	− 396200	+364	∓25	+339 +389	*45.1	+19.7	+ 725.65	+15.83	+0.18	+ 1119600	+400	±72	+472 +328
P_2	5.05	18.20	94,300	5.3	47,700	11,800	6,200	160.1	313.9	22.8	45.2	359.1	207.0	S_1	73.6	5416.96	+15.58	81.98	+17.59	+1294.62	+15.56	−0.02	− 113200	+361	∓ 7	+354 +368	90.1	+19.6	+1442.56	+15.76	+0.18	+ 1119600	+397	±70	+467 +327
P_3	5.10	18.32	98,600	5.5	49,500	13,500	6,500	168.1	482.0	23.7	68.9	550.9	319.1	S_2	73.4	5387.56	+15.38	81.78	+17.39	+1276.43	+15.38	−0.00	0	+355	± 0	+355 +355	89.8	+19.3	+1416.62	+15.52	+0.18	+ 1119600	+391	±69	+460 +322
P_4	5.15	18.46	103,600	5.7	51,300	16,100	6,700	177.7	659.7	24.5	*93.4	753.1	438.8	S_3	73.0	5329.00	+14.98	81.28	+16.89	+1232.97	+14.95	−0.03	− 169800	+351	∓10	+341 +361	89.3	+18.8	+1372.40	+15.11	+0.12	+ 808600	+385	±49	+434 +336
P_5	5.25	18.60	112,000	5.9	53,100	19,000	7,000	191.1	850.8	25.4	118.8	969.6	569.8	S_4	72.4	5241.76	+14.38	80.60	+16.20	+1172.88	+14.33	−0.05	− 283000	+344	∓17	+327 +351	88.5	+18.0	+1303.20	+14.47	+0.09	+ 559800	+380	±33	+413 +347
P_6	5.35	18.75	121,000	6.4	57,600	25,400	7,400	211.4	1062.2	27.5	146.3	1208.5	716.2	S_5	71.6	5126.56	+13.58	79.70	+15.31	+1096.20	+13.55	−0.03	− 159800	+338	∓ 9	+329 +347	87.5	+17.0	+1217.20	+13.67	+0.09	+ 559800	+373	±32	+405 +341
P_7	5.50	18.92	135,700	6.8	61,200	32,100	8,000	237.0	1299.2	29.2	175.5	1474.7	884.0	S_6	70.4	4956.16	+12.38	78.50	+14.11	+ 993.34	+12.48	+0.10	+ 565000	+330	±30	+360 +300	85.1	+15.6	+1098.24	+12.53	+0.15	+ 633000	+364	±34	+398 +330
P_8	5.70	19.09	155,500	7.2	64,800	43,700	8,500	272.5	1571.7	31.0	206.5	1778.2	1083.2	S_7	68.8	4733.44	+10.78	76.80	+12.41	+ 853.81	+10.98	+0.20	+ 113200	+322	±57	+379 +265	84.3	+13.8	+ 949.44	+11.08	+0.20	+ 1866000	+354	±94	+448 +260
P_8^2					129,600	14,300 141,000	2,200	287.1	1858.8	61.8	268.3	2127.1	1085.9	S_8	66.9	4475.61	+ 8.88	74.74	+10.35	+ 692.42	+ 9.16	+0.28	+1585000	+312	±74	+386 +238	81.9	+11.4	+ 762.66	+ 9.16	+0.28	+ 1740000	+343	±81	+424 +262
P_9	7.00	19.29	189,200	8.2				189.2	2048.0			2316.3	1286.7	S_9	64.4	4147.36	+ 6.38	71.70	+ 7.31	+ 470.76	+ 6.47	+0.09	+ 509000	+300	±21	+321 +279	78.2	+ 7.7	+ 495.88	+ 6.19	−0.19	− 1183000	+331	∓49	+282 +380
P_{10}	7.35	19.53	236,000	9.4				236.0	2284.0			2552.3	1522.7	S_{10}	60.9	3708.81	+ 2.88	67.60	+ 3.21	+ 195.49	+ 2.84	−0.04	− 226400	+285	∓ 8	+277 +293	73.7	+ 3.2	+ 194.88	+ 2.57	−0.31	− 1930000	+314	∓72	+242 +386
P_{11}	7.75	19.81	300,600	11.0				300.6	2584.6			2852.9	1823.3	S_{11}	56.0	3136.00	− 2.02	62.00	− 2.39	− 133.84	− 2.12	−0.10	565000	+282	∓17	+265 +299	67.5	− 3.0	− 168.00	− 2.41	−0.39	− 2425000	+300	∓73	+227 +373
P_{11}^2					225,000	256,500	29,500	511.0	3095.6	107.5	375.8	3471.4	1861.9	S_{12}	49.0	2401.00	− 9.02	53.74	−10.65	− 521.85	− 9.43	−0.41	−2320000	+268	∓67	+201 +335	58.1	−12.1	592.90	− 9.72	−0.70	− 4254000	+287	∓125	+162 +412
P_{12}	8.20	20.14	388,200	12.8				388.2	3483.8			3859.6	2250.1	S_{13}	39.0	1521.00	−19.02	42.20	−22.19	− 865.41	−19.63	−0.61	−3450000	+272	∓85	+187 +357	45.7	−24.8	− 937.20	−19.92	−0.90	5600000	+300	∓139	+161 +439
P_{13}	8.70	20.54	513,500	14.6				513.5	3997.3			4373.1	2763.6	S_{14}	23.1	533.61	−34.92	24.40	−39.99	− 923.77	−35.37	−0.45	−2550000	+265	∓54	+211 +319	25.4	−44.1	1014.50	−35.45	+0.47	+ 2920000	+290	±62	+352 +228
P_{13}^2					225,000	394,500	29,500	549.0	4646.3	107.5	483.3	5129.6	2943.6	S_{15}	0.0	0.00	−58.02	0.00	−64.39	0.00	−57.00	+1.02	+5775000	+275	±97	+370 +176	0.0	70.5	0.0	56.20	+1.72	+10700000	+295	±180	+475 +115
P_{14}	9.30	20.99	731,000	17.8				731.0	5377.2			5860.6	3674.6																						
P_{14}^2					225,000	638,500	29,500	893.0	6270.3	107.5	590.8	6861.1	4084.6																						
P_{15}	9.90	21.68	961,000	18.2				961.0	7231.3			7822.1	5045.6																						

For Dead Lord + Half Live Load Stresses

Division of Arch Ring	y Ordinate L	y Ordinate R	Difference of y Ordinates	x	[illegible]	n Ordinate L	n Ordinate R	Difference of n Ordinates	m	m Ordinate L	m Ordinate R	[illegible]	m
S₀	86.02	86.02	0.00	0.0	0.00	16.85	16.85	0.00	0.0	+9.35	+9.35	+18.70	+1378
S₁	85.88	86.20	0.32	5.2	1.66	32.50	35.00	2.50	13.0	+18.60	+18.80	+37.40	+2750
S₂	85.5[illegible]	86.0[illegible]	0.54	10.5	5.67	31.20	36.20	5.00	52.5	+18.20	+18.60	+36.80	+2700
S₃	84.8[illegible]	85.75	0.92	16.0	14.75	29.90	37.60	7.70	123.0	+17.60	+18.20	+35.80	+2615
S₄	84.02	85.08	1.06	21.7	22.80	28.50	39.00	10.50	228.0	+16.80	+17.50	+34.30	+2485
S₅	82.95	84.2[illegible]	1.30	27.6	35.80	27.10	40.40	13.30	367.0	+15.80	+16.70	+32.50	+2325
S₆	81.57	83.0[illegible]	1.46	34.0	49.60	25.60	41.90	16.30	554.0	+14.50	+15.40	+29.90	+2105
S₇	79.67	81.4[illegible]	1.76	40.8	72.00	23.90	43.50	19.60	802.0	+12.70	+13.70	+26.40	+1820
S₈	77.40	79.24	1.84	48.0	88.20	22.20	45.30	23.10	1108.0	+10.50	+11.50	+22.00	+1470
S₉	74.1[illegible]	75.77	1.64	56.3	92.10	20.20	47.30	27.10	1525.0	+7.10	+8.00	+15.10	+970
S₁₀	69.75	71.55	1.80	65.7	118.30	17.90	49.50	31.60	2075.0	+2.80	+3.70	+6.50	+385
S₁₁	63.8[illegible]	65.67	1.84	76.7	141.00	15.20	52.20	37.00	2835.0	−2.90	−2.20	−5.10	−285
S₁₂	55.20	56.94	1.74	89.4	155.50	12.20	57.30	45.10	4025.0	−11.60	−11.20	−22.80	−1115
S₁₃	43.14	44.76	1.62	104.0	168.50	8.70	58.80	50.10	5200.0	−23.30	−23.50	−46.80	−1830
S₁₄	24.92	25.88	0.96	121.8	117.00	4.30	63.10	58.80	7175.0	−41.60	−42.50	−84.10	−1935
S₁₅	0.00	0.00	0.00	140.0	0.00	0.00	67.40	67.40	9415.0	−66.40	−68.45	−134.85	0

Division of Arch Ring	d Ordinate L	d Ordinate R	Eccentricity L	Eccentricity R	Moment L	Moment R	Direct Stress L	Direct Stress R	Eccentric Stress L	Eccentric Stress R	Direct + Eccentric Stress L	Direct + Eccentric Stress R
S₀	+15.63	+15.63	0.02	0.02	119600	−119600	+385	+385	∓8	±8	+377 +393	+377 +393
S₁	+15.55	+15.72	−0.05	+0.14	179400	+837200	+381	+381	∓11	±53	+370 +392	+434 +328
S₂	+15.22	+15.55	−0.16	+0.17	956800	+1016600	+375	+375	∓59	±63	+316 +434	+438 +312
S₃	+14.72	+15.22	0.26	+0.25	1551800	+1495000	+371	+371	∓94	±90	+277 +465	+461 +281
S₄	+14.05	+14.63	0.32	+0.25	−1973400	+1495000	+364	+364	∓115	±88	+249 +479	+452 +276
S₅	+13.22	+13.96	0.36	+0.38	2152900	+2272400	+358	+358	∓121	±128	+237 +479	+486 +230
S₆	+12.12	+12.87	0.26	+0.49	1551800	+2930200	+350	+350	∓84	±157	+266 +434	+507 +193
S₇	+10.62	+11.45	0.16	+0.67	956800	+4005600	+340	+340	±48	±202	+292 +388	+542 +138
S₈	+8.72	+9.63	0.09	+0.75	538200	+4185000	+330	+331	∓25	±208	+305 +355	+539 +123
S₉	+5.94	+6.69	0.44	+0.31	−2635000	+1857000	+316	+318	∓110	±78	+206 +426	+396 +240
S₁₀	+2.34	+3.10	0.54	+0.22	3235000	+1320000	+300	+302	∓120	±49	+180 +420	+351 +253
S₁₁	2.42	1.84	0.40	+0.18	−2392000	+1070000	+295	+300	∓72	±32	+223 +367	+332 +268
S₁₂	−9.70	9.38	0.68	0.36	1070000	2150000	+273	+285	∓117	±62	+156 +390	+223 +347
S₁₃	19.50	−19.95	−0.18	0.63	2880000	+3780000	+282	+290	∓71	±94	+211 +353	+196 +384
S₁₄	34.80	35.55	+0.12	0.63	719000	−3770000	+274	+281	±15	±80	+289 +259	+201 +361
S₁₅	55.52	57.20	−2.50	+0.82	+1498000	+4910000	+282	+291	±250	±82	+532 +32	+373 +209

Stresses for Arch Rib Spandrel Piers and Walls over Crown of Arch

Division of Arch Ring	y Ordinate	m Ordinate	m	d Ordinate	Eccentricity	Moment in [illegible]	Direct Stress	Eccentric Stress	Direct + Ecc. Stress
S₀	24.0	+14.6	+5[illegible]8	+15.65	0.00	0	+240	0	+240 +240
S₁	67.[illegible]	+14.5	+1067	+15.55	+0.02	+111900	+228	7	+245 +231
S₂	67.7	+14.2	+1050	+15.34	+0.04	+179200	+234	8	+242 +226
S₃	67.[illegible]	+13.[illegible]	+1015	+14.91	+0.07	+241100	+231	16	+247 +215
S₄	66.8	+13.4	+970	+14.37	+0.01	+37[illegible]00	+227	2	+229 +225
S₅	66.0	+12.6	+901	+13.51	+0.07	+241100	+223	15	+238 +208
S₆	65.0	+11.6	+81[illegible]	+12.44	+0.06	+227800	+218	12	+230 +206
S₇	63.6	+10.2	+70[illegible]	+10.94	+0.16	+596800	+212	30	+242 +182
S₈	61.8	+8.4	+562	+9.01	+0.17	+484000	+20[illegible]	[illegible]	+22[illegible] +18[illegible]
S₉	59.2	+5.8	+372	+6.22	0.15	+54000[illegible]	+19[illegible]	2[illegible]	+173 +219
S₁₀	56.1	+2.7	+165	+2.90	+0.02	+71[illegible]00	+188	3	+191 +185
S₁₁	51.1	2.0	112	2.15	0.1[illegible]	485000	+182	15	+167 +197
S₁₂	44.[illegible]	−8.5	−417	−9.12	−0.10	−375000	+175	11	+164 +186
S₁₃	35.1	18.0	702	19.20	0.24	8[illegible]7000	+176	22	+154 +198
S₁₄	20	32.7	735	35.10	0.18	671000	+177	14	+163 +191
S₁₅	0.0	53.4	0	57.20	+0.72	+2680000	+18[illegible]	4[illegible]	+2[illegible] +142

Maximum & Minimum Stresses

Division of Arch Ring	Temperature Stress	Stress Due to Shortening from Thrust	[illegible]	Max. [illegible] Stress	Min. [illegible] Stress
S₀	60	50	27	+627 +410	+302 +173
S₁	6[illegible]	58	25	+618 +427	+219 +177
S₂	65	55	24	+60[illegible] +456	+2[illegible] +104
S₃	62	54	21	+597 +435	+2[illegible] +145
S₄	59	49	19	+5[illegible]8 +507	+221 +150
S₅	52	44	17	+5[illegible] +504	+212 +117
S₆	46	40	15	+607 +475	+244 [illegible]
S₇	35	31	12	+622 +406	+274 +58
S₈	25	23	10	[illegible] +3[illegible]	+2[illegible]1 +63
S₉	18	15	8	+4[illegible]7 +435	+195 +190
S₁₀	7	6	6	+370 +427	+173 +274
S₁₁	4	3	5	+341 +388	+208 +2[illegible]
S₁₂	18	15	11	+2[illegible]7 +476	+112 [illegible]
S₁₃	32	27	14	+240 +512	+88 +414
S₁₄	51	43	19	+379 +474	+88 +2[illegible]2
S₁₅	[illegible]	[illegible]	24	+5[illegible] +355	+224 [illegible]

NOTE.—*Half Moment Ordinate. †Moment Ordinate squared ÷ 2. Moments indicated + when pressure curve is above neutral axis and − when below axis. Stresses indicated + for compression and − for tension. Where two stresses are given in one space the upper is for extrados, the lower for intrados.

cluding the roadway slab are plain concrete.

From the preceding the general structural features of the Rocky River arch are sufficiently plain for an understanding of the stress computations which follow.

Materials.—The concrete for the main arch ribs is a 1-2-4 limestone mixture capable, it is considered, of developing strengths per square inch of 1200 [illegible] 2000 lbs. in 30 days, 2800 lbs. in three months and 3500 lbs. in six months. A unique feature of the arch rib construction is that slabs of stone will be embedded in the concrete in radial positions and [illegible] together, in a word the arch rings will be of a special rubble concrete.

So far as we know the only precedent is the Walnut Lane Bridge of 233 ft. span recently constructed at Philadelphia, Pa. The purpose of this rubble is to increase strength and not primarily, as is ordinarily the purpose of rubble, to cut down the cost of the concrete work. Tests made on cubes show that failure comes generally by diagonal shear. If some resistance in the form of steel or flat stones is introduced normal to the shearing stress the ultimate strength of the construction is considerably increased. An arch ring is a column with a shearing force added to the direct compressive stress. The shearing stresses at the springing lines of this arch are excessive for plain concrete, and as it was impracticable to increase the thickness of the ring some form of reinforcement was imperative. Steel placed radially to restrain the concrete laterally would accomplish this, but the same effect is obtained in a much more economical manner by the use of the radial slabs.

The concrete for footings and foundations is a 1-3-5 concrete with embedded rubble stones less than 1x2x3 ft., placed not less than 3 ins. apart in all directions.

The concrete for piers, abutments and spandrel walls is a 1-3-5 mixture with one-man rubble stones embedded not less than 3 ins. apart or from the surface.

The concrete for roadways, sidewalks, brackets under balusters and secondary arch rings is a 1-2-4 broken limestone mixture.

The concrete for all exterior surfaces for 1 in. in depth on vertical surfaces and for 1½ ins. in depth on horizontal surfaces is a 1-2-2 granolithic ¼-in. stone mixture. This finish will be placed on horizontal surfaces by troweling before the concrete has set and on vertical surfaces simultaneously with the backing.

Assumptions for Calculations.—For dead load the concrete in the main arch ribs was assumed to weigh 160 lbs. per cu. ft. and all other concrete 150 lbs. per cu. ft. The safe compressive strength of the concrete was assumed to be 600 lbs. per sq. in. The 60-ton street cars were assumed to produce for each half of the bridge to one side of the center line an equivalent uniform live load as follows: For the 40 ft. width of roadway next the center line, 270 lbs. per sq. ft., for the next 10 ft. of roadway, 100 lbs. per sq. ft., and for the 8-ft. sidewalk, 80 lbs. per sq. ft. The wind load was assumed to be 30 lbs. per sq. ft. of vertical surface.

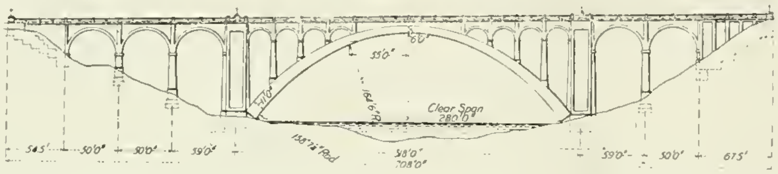


Fig. 1—Diagram Elevation of 280-Ft. Span Concrete Arch Bridge at Cleveland, O.

Determination of Stress.—Determinations were made (1) for dead load stresses; (2) for dead load plus live load stresses; (3) for dead load plus one-half live load stresses; (4) for dead load of arch ribs, spandrel piers and walls; (5) for temperature changes; (6) for stresses due to shortening from thrust, and (7) for wind stresses. The complete analysis of stresses is shown by the accompanying tables: The stress sheet for the main span is shown by Fig. 2. The quantities in the tables are taken from this stress sheet. The notation is as follows:

y ordinate = distance from neutral axis to span line of linear arch.

z ordinate = distance from pressure curve to span line of basic polygon.

k ordinate = distance from neutral axis to closing line of neutral axis polygon.

Eccentricity = $a - k$.

m ordinate = distance from pressure curve to closing line of basic polygon.

c = distance from span line of linear arch to closing line of neutral axis polygon.

Moment = eccentricity × true pole distance.

Assume pole distance H = 5,000,000 lbs.

To compute the true pole distances, the value of Σy, Σy^2, and $\Sigma m y$ were determined for loadings 1, 2 and 3 noted above. For example, for dead load stresses: $\Sigma y = 1{,}798.69$; $\Sigma y^2 = 117{,}601.34$; $\Sigma m y = 14{,}965.96$; $c = 58.02$. Thus.

$$\frac{\Sigma y^2 - c\Sigma y}{\Sigma m y} = \frac{13241}{14966} = 0.882$$

$$\frac{\Sigma m y}{\Sigma y^2 - c\Sigma y} = \frac{14966}{13241} = 1.13$$

True $H = 5{,}000{,}000 \times 1.13 = 5{,}660{,}000$ lbs.

Stresses due to temperature changes were calculated from the equation

$$H = \frac{E l \Delta t}{\Sigma y^2 - c\Sigma y} \quad \frac{I}{S}$$

in which

$E = 288{,}000{,}000$ lbs. per sq. ft.

$l = 280$ ft.

$\Delta = 0.000006$ per degree Fahrenheit.

$t = +30°$ F.

$\frac{I}{S} = 62.33$ per rib.

$\Sigma y^2 - c\Sigma y = 13{,}241$, and

$H = 68{,}300$ lbs. per rib.

The stress due to shortening of arch rib from thrust was taken as 85 per cent of temperature stresses due to 30° fall of temperature.

Construction.—Work is in progress on the foundations for the main arch span; they will be bedded on shale rock 24 ft. below the surface of the river. The foundation load will be 6½ tons per sq. ft. Each rib of the arch will be built separately on a steel center which will be moved from under the first rib to under the second rib. The center consists of two three-hinged steel trusses spaced 23 ft apart and carried on shoes on a shoulder or ledge on the main abutments. The trusses are braced together and carry two

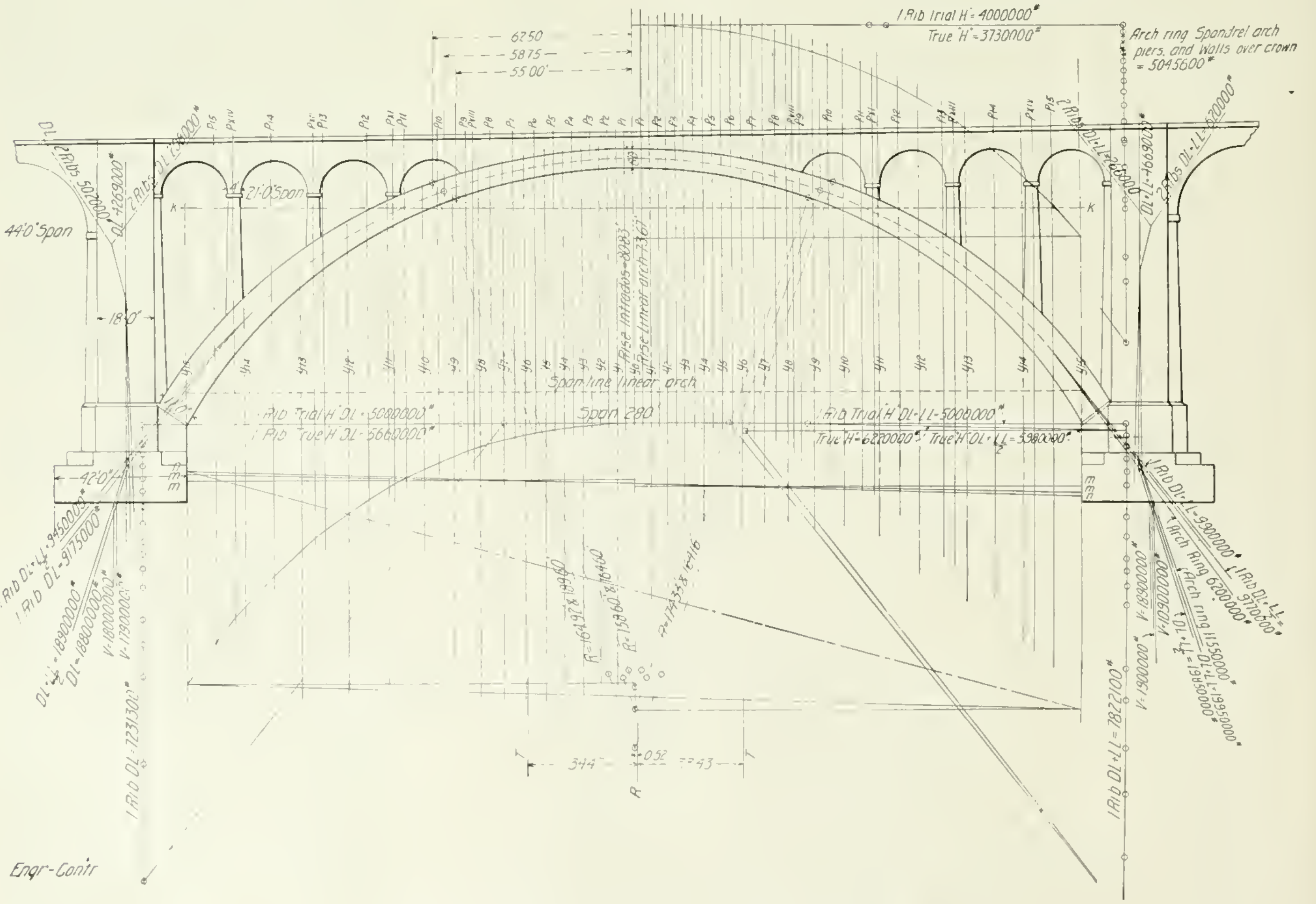


Fig. 2—Stress Sheet for 280-Ft. Span Concrete Arch.

lines of stringers on which stand the arch rib forms. The shoes of the trusses will rest on jacks to permit positive and uniform lowering of the center. The arch rib will be concrete in transverse sections, two corresponding sections, one on each side of the crown, being concreted simultaneously.

The bridge was designed under the direction of Mr A B Lea, engineer of Cuyahoga County, by Mr A M. Felgate, bridge engineer of that county. The contract for the construction was awarded to the Schillinger Brothers Co., of Columbus, O., for $208,302. Mr Wilbur J Watson is engineer for the contractors.

Relations of Temperature to Time of Set and Strength of Concrete.—The following tests made by Mr H. L. Sherman, cement chemist, for the Aberthaw Construction Co., of Boston, Mass. They are a continuation of an elaborate set of tests and show results at the age of three months. The table follows:

Temp. of. air and mat	Mixture	Strength lbs per sq in
72°	Neat	759
72°	1:3	305
41°	Neat	660
41°	1:3	303
34°	Neat	567
31°	1:3	249
11° (room, 7°)	Neat	29
	1:3	9

It was noted from the early tests that at a temperature of 72°, the cement showed a decrease in strength from 7 days to 28 days on the neat tests, while on the mortar tests the strength was the same. On the tests at 41°, there was a good increase between these periods on both sand and neat tests, and at 31°, a better percentage increase on both. In the opinion of the chemist this is an illustration of the importance of water on the early strength of cement. At 72°, the excess water contained in the briquettes was evaporated rather quickly, while at the lower temperatures, the rate of evaporation was very slow. Between 28 days and 3 months, the briquettes at 72° showed a very good increase, those at 11° a less decided increase, and those at 31° still less. Apparently cement at low temperatures (above freezing however) attains less strength than at a normal temperature but its increase in strength in short times is greater.

The U. S. House of Representatives has passed the substitute Forestry Bill. The bill provides for an annual appropriation of $1,000,000 for the preservation of forests in those states which have fire protection laws. The bill calls for a commission of government officials to supervise the expenditures from the forest reserve fund.

Earth and Rock Section

Note: This Section is devoted to methods and costs of excavating earth and rock and building embankments. It will cover the grading of roads and railroads, diking and canal work, dredging, building reservoirs and earth dams, sewer and water pipe trenching, quarrying, etc.

Comments on Dump Wagons.

(Continued from p. 117, Feb. 21, 1909.)

The first group of wagons we will describe will be bottom dump wagons. These will be divided into two sections: Dump wagons proper and dump boxes.

The National dump wagon is manufactured by the Indiana Road Machine Co., Fort Wayne, Ind. The distinguishing feature of this wagon is its hinges on the steel doors and the method of winding of the doors, and keeping the chains tight. For hinges vertical slide guides are fixed to the sides of the wagon, and loops attached to the doors, operate around the guides on the outside of the wagon. The lifting chains are not long enough to allow the doors to drop to a vertical position, and as a result, when the load is dumped, the doors are forced by the weight of the falling material up and outside of the box, and are lifted clear of the dump. Thus all possibility of the wagon being stalled is avoided. When the wagon is free from the dumped load the doors assume a half closed position, thus allowing them to be closed with about three full throws of the lifting lever.

The doors are of steel and overlap, one door always closing before the other. The lifting chains all have turn buckles in them so if the chain becomes stretched from use they can be tightened so that there is no play of the doors, allowing leaks. The pull of the chains, both in the front and rear, is straight up thus making the doors work easy and holding them well in place. One lever dumps the load and another winds up the doors. This wagon has a short wheel base, namely 8 ft. 3 ins., and without side boards is 4 ft. 4 ins. high.

The National is made in 3 sizes, namely, 1¼, 1½ and 2 cu. yds. For country use the wagon is made in the 62 in. gage, wooden axle, and a patented drop, tongue that allows of free play but prevents the horses carrying all the weight of the tongue on their necks. They can be fitted up for either a 2 or 3-horse hitch. For city use the gage is 56, a stiff tongue is used and the wagon has steel axles.

The Troy dump wagon is manufactured by the Troy Wagon Works Co., of Troy, Ohio. The distinguishing feature of the Troy is the tubular bar on the side of the wagon that dumps the loads and winds up the doors. The doors are made of steel and overlap 2 ins. or more, one door closing before the other, thus making them tight and preventing leaks. The doors also come up over the edge of the box of the wagon. The tubular bar running lengthwise of the box has a spiral drum and a chain attached to each end, and is controlled by a lever in connection with a pawl and ratchet. This bar and the short chains allow of little lost motion, and thus the doors are closed with little power and great speed. The chains must follow the spiral grooves and wind at both ends simultaneously. Steel doors are considered an advantage over wooden doors, as the latter may swell from being wet. The wagon is ironed throughout with forged steel. The front end of the wagon box is supported by riveting two pieces of heavy sheet steel to the front, or neck, of each side board.

A Troy wagon was tested in the laboratory for testing materials of Purdue University, and stood a load of 72,500 lbs., the bottom sagging 0.35 ins. without leaking sand. The rear axle has springs on it, or springs can be ordered on any wagon. This makes the draught easy. The Troy Co. build 14 different styles of bottom dump wagons, varying in capacity from 1½ to 5 cu. yds., and weighing from 5,000 to 10,000 lbs. The length of wheel base varies from 8 ft. 4 ins. to 9 ft. 4 ins. The popular wagon for contracting purpose is a 1½ cu. yd. capacity wagon, 4 ft. 8 ins. high, with a wheel base of 8 ft. 4 ins.

The Studebaker Patent Improved [illegible] Dump Wagon is manufactured by the Studebaker Bros. Co. of South Bend, Ind. The name of Studebaker is so well known, in connection with vehicles of all kinds, that it is not surprising that when there was a demand for dump wagons this company placed one on the market. A distinguishing feature of the wagon is the absence of any chains on the sides of the wagon. The dumping chain runs under the doors, which are wood covered with steel, and are so arranged that one door is closed before the other, thus permitting a lap to be made, thus preventing the body from leaking. The manufacturers pride themselves on the material used throughout in building their wagons. All important metal parts are made of wrought iron or steel, so repairs, when necessary, can readily be made by any blacksmith.

The dumping attachment consists of one roller with winding arbor and ratchet attached; one chain; one dumping and one winding lever and safety device. A load cannot be dumped accidentally, and the doors can be wound up quickly. The neck of the wagon is lined with steel on both sides, and further reinforced by a heavy rocker plate, all firmly riveted and bolted together. The winding roller although it goes through the sides of the body, is in front of the neck, so the neck is in no way weakened.

The front axle has a bolster on it, thus raising up the tongue of the wagon, and as the fifth wheel is a large circle, it keeps the front carriage in proper position, and prevents the front end of the tongue from dropping down. Either a drop pole or a stiff or coach pole is furnished with the wagon. The wheel base of the wagon is 8 ft. 6 ins. The wagon is made in two sizes, namely 1½ and 2 cu. yds. capacity. The axles are made of steel. These wagons weigh from 1,850 to 2,150 lbs. The height of these wagons without side boards is 4 ft. 3½ ins. The ordinary side boards used are about 6 ins. high.

The Austin dump wagon is manufactured by the Austin Manufacturing Co., of Harvey, Ill. The Austin Co. claim to have the pioneer dump wagon. The distinguishing feature of the Austin is the chain hinges, that allow the doors when they are dumped to be pressed up against the sides of the wagon by the dumped load, thus preventing the load pressing the doors against the wheels, when hard material is being hauled, and stalling the team. These chains and also the winding chains are on both sides of the wagon. On the ends of each door there is a steel arm or wing that serves to raise the doors and firmly wedge them into place when loaded. Until these arms are destroyed there can be neither crack nor crevice out of which sand or loose material can leak. The wagon is dumped and brought back into loading condition by a single lever.

The box is made of fir bound together with angles in corners and entirely around the bottom of box, bolted iron to iron, to prevent spreading or getting out of shape A heavy steel gooseneck is built into each side of the wagon. The Austin wagon is made in two sizes, 1½ cu. yds. and 2 cu. yds. The first is known as the contractor's wagon, the second as the municipal wagon. The contractor's wagon weighs 1,750 lbs., and has a wheel base of 8 ft. 4 ins., thus making it of easy draft. The height to the top of the base is 4 ft. 5 ins. and with side boards 5 ft. Turnbuckles are used in each adjusting chain to take up all wear and keep them tight. The manufacturers claim that their wagon is unequaled for heavy teaming in bulk over rough paved streets.

The Watson Dump Wagon is manufactured by the Watson Wagon Co., Canastota, N. Y. This company claims to be the pioneer in the bottom dump wagon business. For years the distinguishing feature of the Watson has been the link belting, on the side of the green wagon body, that was part of the dumping and winding up gear. Within the last couple years this link belt has been taken off of their latest model, and a straight chain used under the wagon to wind up the doors. This makes a wagon without chains on either side. When this change was made in the wagon a new dump and lock device was also put on the wagon. The lock which is used in connection with this device operates automatically when the bottoms are raised and the lock catch can be instantaneously released when load is to be dumped. The lock must be released before the foot dump can be operated. This arrangement prevents the load dumping accidentally. The foot dump is of special design, is quick in action and reliable.

The boxes are built of selected birch timber. All parts of the wagon can be secured of the manufacturers, so that quick repairs can be made, and these parts are made so that they fit without alterations. The Watson wagon, although built strong, and well ironed wherever necessary, yet is very light in weight. Making 11 styles or types of wagons, ranging in capacity from 1½ to 5 cu. yds., the weight runs only from 1,800 to 2,800 lbs. The wagons are built either with drop or stiff pole. The height of the 1½ cu. yd. wagon is 4 ft. 8 ins. The axles are steel. The company has records of large loads hauled on these light wagons. Their slogan is. "First in the field, last in the repair shop."

The Star Dump Wagon is built by the Glen Wagon Co., Seneca Falls, N. Y. This company claims their wagon is the design of the pioneer in the dump wagon building. The Star wagon has a straight chain running under the doors to dump them and wind them up. The doors overlap about 2 ins., preventing them from leaking. The tongue of the wagon is high, preventing it hitting the horses' legs. The wagon has a 30-in. platform circle, which makes a broad bearing, carrying the pole stiff at all angles. The pole can be made stiff or drop by use of a thumb-screw on the butt of the pole. There is a rocker device in the front that equalizes the load in going over rough ground, thus preventing wear on the wagon.

The neck is said to be built very strong, being only 14 ins. long from the end board to the front bolster, the 2 x 12-in. plank being reinforced with boiler plate. All the irons on the wagon are wrought forgings. In the rear of the wagon there is a spring that brings the doors up in their proper order, also grab hooks that permit the lowering of the doors part way only, so as to streak the load along instead of dropping it in a pile. This wagon on account of the strength given by the short, strong neck is recommended by the makers for steam shovel work. The wagon is built in eight sizes from 1½ to 5 cu. yds., weighing from 1,800 to 3,000 lbs. The dumping device has a positive lock on it preventing accidental dumping. A 1½-cu. yd. wagon has a wheel base of 7 ft. 10 ins. or 8 ft. only, thus making a light draft wagon. This company makes a 3-horse hitch with two poles.

This company also makes another style of dump wagon, known as the "Atkins Spreading Wagon." The doors are hung across the wagon instead of lengthways, both doors being operated by a single chain on each side of the wagon. By opening the door but part way the material can be spread out over a considerable area. The door can also be released and the entire load dumped. For these reasons this wagon is known as a combination dumping and spreading wagon. In other details it is built like their regular contractor's dump wagon that we have already described.

The Aurora Dump Wagon is manufactured by the Western Wheeled Scraper Co., of Aurora, Ill. Their old pattern wagon, which they still make, has chains on the inside of the dump box, but their new pattern is without chains on the inside. The distinguishing feature of the Aurora is the hinge, which is a piece of malleable T-iron running under the door and curving around the edge of the box, fitting into a groove, that allows it to slide up well on the side of the box, allowing the doors to clear the load when dumped, and preventing the wagon from being stalled by the dumped load. The chains operating the doors run along the sides of the wagon and at each end are fastened to two bars that cross one another, so that the chains on one side operate the door on the other side of the wagon. There is a spiral guide on the roller, causing the chain to wind up smoothly without piling up.

The tongue is of the same height as the front axle, and is also supported from the wagon body by a chain with a spiral spring on it. The manufacturers claim that the opening for discharging the load is larger than any other wagon of the same capacity. For the 1½-cu. yd. wagon the opening is 40 x 47½ ins. and for a 2-cu. yd. wagon, 40 x 60 ins. These two sizes are the standard stock sizes of this company, although they make larger sizes on special orders. The weight of these two wagons are 1,700 lbs. and 2,000 lbs., respectively. The smaller wagon is 4 ft. 3 ins. high without the flare board. The body of the wagon is made of fir, the wheels and other parts of oak.

The Acme Dump Wagon is built by the Acme Wagon Company of Emigsville, Pa. The distinguishing feature of the Acme is that the wagon does not have a neck between the front of the wagon and the dump box, the side has but a small circular piece cut out of it to allow the front wheel to pass under it, in turning. This makes a strong side to the wagon. The doors are of steel and are suspended with three rigid hook hinges, passing through an opening in the bottom, and around heavy tubing on the edge of the door. This tubing forms a strengthening bar for the back edge of door and a large bearing upon which the door swings. The doors overlap, thus making them sand tight.

The dumping chains go under the doors, thus the sides of the wagons are free of chains. The doors are opened by means of a foot trip and closed by means of a lever. The tongue sits high above the front axle. The axles are of tubular steel. The wagon is made in two sizes, namely 1½ and 2 cu. yds. capacity. The 1½-cu. yd. wagon is 4 ft. 4 ins. in height, exclusive of side boards.

In addition to this wagon the Acme Wagon Co. also make the Acme stone spreading dump wagon. It differs from the contractor's dump wagon by having a hopper shaped compartment under the box which is closed by two steel doors running across the wagon. The chains to operate these doors are on the outside of the box, and are arranged on the two sides. The doors are opened and closed by means of worm gears, and the operation is entirely under the control of the driver. Stone and other material can be spread very evenly. The inside of the box is lined with steel. The wagons are made of 1½, 2, and 2½ cu. yds. capacity. They are built, as to other details, in a manner similar to the regular Acme dump wagon.

The Milburn dump wagon is manufactured by the Milburn Wagon Co., of Toledo, Ohio. This company has been well known in the wagon business for more than 50 years. The Milburn wagon has no chains on the sides, and the doors are lowered and wound up by a single chain, running from a drum in front of the wagon under the doors and through two pulleys or sheaves on each end of the box. One lever controls the dumping device and in winding up the doors the arrangement of the chain and pulleys resembles a block and tackle, so that it takes but very little effort to make the doors almost water tight. The doors can be wound up while the horses are walking 100 ft.

The wagon is ironed with wrought iron so that repairs can be made to the wagon by any blacksmith. This also applies to the hinges of the wagon. The neck of the wagon is ironed both on the inside and outside with heavy plates of sheet steel. The main weight of the load in a dump wagon is carried on the rear axle. For this reason the back axle on the Milburn is built especially strong and the wagon body is fastened to the axle with heavy wrought iron. On account of the large amount of wrought iron used in the construction of this wagon, it is sometimes called the "wrought iron wagon."

The Milburn wagon is built in two sizes, namely 1½ and 2 cu. yds. capacity, but larger sizes are made to order. The manufacturers state that the lumber used in the construction of their wagons is specially selected from large tracts of timber that are owned by themselves. The timber is seasoned by their own methods.

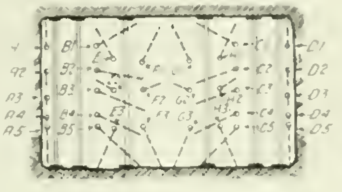
(To be continued.)

The New York State Highway Commission intends to inaugurate a patrol system for the maintenance and repair of improved highways and will employ 180 men, each under contract to keep in repair about ten miles of highway. Each will have a horse and cart and be required to go over his section daily, with necessary devices to keep the road in proper condition.

Method of Driving a Submarine Slope Tunnel.

The following methods of driving a tunnel by the Nova Scotia Steel and Coal Co. is used at their submarine mine on Bell Island. This company owns 32 square miles of submarine ore beds. The method of working is as follows:

Three eight-hour shifts are worked. When the air is cleared of smoke from the last shot, the drillers and loaders proceed to the face. The drillers and their helpers begin to assemble their drills and columns, while the loaders employ themselves in throwing back the ore from the face. The drills, of which there are two on this shift, are then set up 4 ft. from the face and about 20 ins. from the rib or side, and each puts in five 12-ft. center cut holes, B 1, 2, 3, 4, 5, and C 1, 2, 3, 4, 5, respectively, completing the round in about 6 hours. The holes are blown out with compressed air when the shift is completed.



END ELEVATION

After having cleared away the face for the drillers the loaders, six in number, clear off the track and run in a trip of three cars. They load up the ore that has been thrown up the slope by the previous blast, which sometimes is as much as 100 ft. from the face. When the ore is reduced to a heap behind the drillers one car only is used, and the loaders relieve each other car about, three at a time. The loaders generally finish at the same time as the drillers. Forty to fifty tons is an average shift's work.

The blasters then load the holes drilled with 7 lbs. of 50 per cent Acadia dynamite in each, tamping them securely with paper cartridges of clay prepared for the purpose. After the wires and blasting machinery are tested for strength and circuit the round is fired. If the work has been done correctly, the center cut will be taken out as shown in the sketch, and the ore thrown well up the slope. Owing to the heavy burden on these holes they will be only about half shot out. A little high pressure air is turned on at the face immediately after the blast, and the exhaust fans speeded up. In the course of a short while the air at the face is quite clear, and while still a little warm, work can be resumed.

The next shift then begins, loaders clearing face as before.

The usual drillers now set their bars 4 ft. back from the face and as close to the rib as possible, and drill holes A 1, 2, 3, 4, 5, and D 1, 2, 3, 4, 5, 12 ft. deep. In addition to these two spare drills are set up in the cut and drill holes E 1, 2, 3, F 1, 2, 3, G 1, 2, 3, and H 1, 2, 3, respectively, 6 ft. deep. As the extra drills do not come on the same shift each time there are two spare drillers on each shift, and when not employed at this work they are kept busy repairing and advancing ventilating pipes, swinging [illegible], etc., and other odd jobs.

The order of blasting is now more elaborate than on the previous shift, and on the care taken in this work greatly depends the advance to be gained.

They first load and fire first holes F 1, 2, 3, and G 1, 2, 3, 3 lbs. to a hole. Next they fire the old bottoms of holes B 1, 2, 3, 4, 5, and C 1, 2, 3, 4, 5, with 3 to 5 lbs. each, according to necessity. The third round is E 1, 2, 3, and H 1, 2, 3, 5 lbs. to a hole, and finally A 1, 2, 3, 4, 5, and D 1, 2, 3, 4, 5, are fired, 5 lbs. to a hole. This makes a total of about 200 lbs. of 50 per cent dynamite to an advance of 8½ to 9 feet, according to the success of the work done, making 5 lbs. of 50 per cent dynamite to each cubic yard of material excavated.

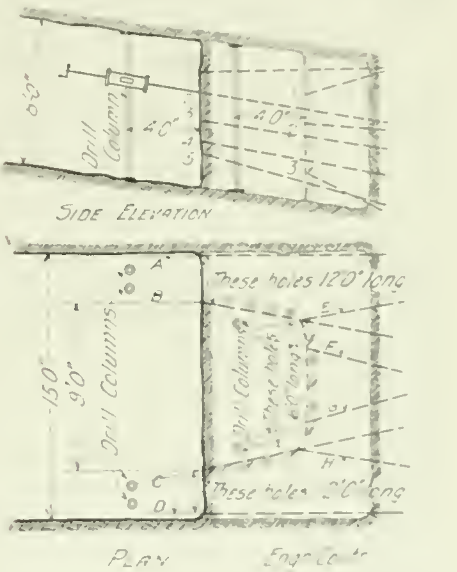


Diagram of Arrangement and Location of Blast Holes.

The method of using short bars and setting up the drills on top of the ore heap was tried for some considerable time at first, but it was found that while saving a good deal of time in handling the ore, in the long run it did not pay.

The storage, thawing and distribution of the explosives for both the mines and the submarine slope is carried on at a central station, which comprises a small magazine, thawing house, with detached boiler room, and a shed for testing detonators located at convenient distances apart.

The thawing is carried on in a small stone building, brick lined and wood faced inside with an air space between the brick and stone, and the building provided with a large entry for the reception and disposal of the explosive. The heating system is the ordinary hot water system as used in dwellings. The radiators are placed in wooden boxes to prevent accidental contact of the explosive.

The various blasting crews, wiremen, thawer, magazine storekeeper and detonator tester are all under the supervision of an explosive inspector, who constantly inspects all operations connected with the use and disposal of all explosives, and who immediately reports to the underground manager any unusual occurrence, and, if possible, the cause of the same.

The cars used are of steel, of 30 cu. ft. capacity, holding from 1.7 to 1.8 tons of ore, the gage 2 ft. The tracks are of 28 lb. rails, except near the face, where an 18 lb. rail is temporarily used.

Telephones are installed in the slopes, connecting through a central office with all parts of the works, the office and the houses of the manager and underground manager.

The following compressor plant was used: One Nordberg duplex compressor, cross compounded air and steam, jet condenser using fresh circulating water, direct connected to low pressure crosshead of the compressor; steam cylinders, 18—32x42; air cylinders, 19—29x42; capacity, 2,500 cu. ft. of free air per minute. One Walker compressor of same type; steam cylinder, 22, 42x48; air cylinder, 23½, 38x48; capacity, 3,500 cu. ft. of free air per minute; the exhaust steam is conducted to a surface condenser, using salt water from the sea for circulating water. One straightline Norwalk compressor, compound steam, compound air, with a jet condenser using fresh water; steam cylinder, 14—22x24; air cylinder, 14½—22x24; capacity, 1,200 cu. ft. of free air per minute. The total capacity of air compressing plant is 7,200 cu. ft. of free air per minute.

The advances are as follows:

Slope commenced May 21st, 1906. Distance driven to December 31st, 1906, 704.6 ft.; distance driven to December 30th, 1907, 1,916.1 ft.; distance driven to December 24th, 1908, 3,965 ft. The month of least advance was August, 1907, in passing first fault, or 42.5 ft. The month of greatest advance was November, 1908, or 247.81 ft. In the four weeks from the 16th of November to the 14th of December an advance was made of 270.1 ft. In the week ending December 7th, 1908, an advance was made of 72.5 ft. This gives a record of 11¼ ft. per day for a month, and 12 ft. 1 in. per day for a week. The size of excavation for this driving was 13 ft. to 15 ft. wide by 8 ft high.

A system of bonus payments for rapid advance greatly helped in attaining above results.

The above is condensed from a paper prepared for the Canadian Mining Institute by R. E. and A. R. Chambers.

Roads and Streets Section

Note: This Section is devoted to methods and costs of road and street construction. It will cover road building in all its details, the construction of pavements, sidewalks and gutters, the testing and use of paving materials and the machinery and tools used in road building and paving.

Brick Pavement Construction Along Street Railway Tracks at Champaign, Ill.

During last summer John St. in Champaign, Ill., was paved with brick on a concrete base. An interesting feature of the work was the construction of concrete foundation slabs for the rails and ties of the street railway track which was built along the street. The work was described by Mr. G. C. Fairclo, City Engineer of Champaign, in a paper read before the Illinois Society of Engineers and Surveyors, and the matter in this article has been taken from his paper.

The pavement consisted of Culver block laid on a 2-in. sand cushion resting on a 6-in. broken stone concrete foundation. A 70-lb., 7-in. T-rail 60 ft. long was used for the car tracks. The ties were well seasoned oak, 6 in. x 8 in. x 8 ft., excepting at the turn-outs, where sawed ties were used. The ties were spaced 5 ft. center to center, save at the joints, where a tie was placed immediately under the joint, and the ties on each side spaced half way between the joint tie and the second tie on each side. Switch ties were placed 20 in. center to center.

The sub-grade for the street was first finished as if no car track was to be built along the street. Trenches 9 ft. long and 18 in. wide were then dug 5 ft. center to center, to a depth of 19 in. below grade, to provide sufficient space for a concrete foundation slab, 6 in. deep, 18 in. wide and 9 ft. long under each tie. Between the tie foundation trenches and under the position of each rail, a 16-in. wide trench was dug to a depth of 15 in. below grade, to provide space for an 8-in. thick by 16-in. wide foundation slab of concrete under each rail.

The ties and rails were placed as the trenches were completed, and the rail spiked in place, joints being broken 30 ft. After this the track was lined and graded to the surface of the pavement, blocks placed under the ends of each tie and shims being used to bring the track to the required grade. A Foote mixer with flanges placed on its wheels was mounted on the track for the concrete work. The concrete was placed first in the trenches under the ties and rails and thoroughly tamped. The concrete foundation for the roadway on each side of the track was constructed at the same time, the work being kept only far enough back to allow thorough tamping under the ties and rails.

To bring the surface of the concrete to the required crown, forms were dragged over it, one for each side of the roadway, one between the tracks and one between the rails. These forms had runners shod with steel and were made adjustable so that they could also be used for spreading the sand cushion. The roadway forms were so made that one end rested on the concrete gutter and the other end on the track rails. The ends of the forms used on the tracks and between the rails rested on the rails. An advantage of these forms is that the wavy surface often seen on a brick pavement is obviated.

The Culver block was laid as follows:

Where there was single track the brick between the rails and for five courses outside each rail were laid longitudinally along the street and parallel to the rails. From the face of the gutter flag to a line five courses outside of each rail the brick were laid at right angles to the curb, except at street intersections, where they were laid at an angle of 45 degrees to the curb. Along the double track the bricks between the rails of each track and for five courses outside the outside rail of each track were laid longitudinally along the tracks. Between the inside rails of the tracks, with the exception of one course of brick which was laid longitudinally, the bricks were laid at right angles to the curb line. From the gutter flag to a line five courses outside the outside rails the brick were laid at right angles to the curb line. The paving was connected with the car track by the Nelsonville Brick Co.'s filler and stretcher brick. The filler brick fits the web of the rail, and is used in connection with the stretcher brick, which is laid parallel to the rail and against the filler brick, making the proper groove for the car wheel flanges.

Between lines five courses outside of the outside rails Pioneer asphalt filler was used. From these lines to the gutter flag cement grout filler was used. Asphalt filler was used to lessen the noise made by the cars passing over the track and to facilitate the repair of the track, as the brick may be removed without breaking and the filler preserved and remelted and both replaced in the pavement.

Expansion in the grout-filled pavement was provided for as follows: Where single or double street car tracks were built along the street, ½-in. expansion joints were constructed along the face of the gutter between the first and second rows of brick outside of the rails of a single track, and between the first and second rows of brick outside of the outside rails of the double track; also every 25 ft. across the pavement, extending from the gutter flag on each side to a line five rows of brick outside the rail.

The pavement was built by contract, the contract price being $1.62 per sq yd

Economic Hints for Macadam Road Contractors.

(Continued from March 3 issue)

25 If it becomes necessary to place the rock crusher in a quarry pit, thus involving a steep pull to get out of the pit, load the wagons heavily and use either a hoisting engine or a snatch team to assist the teams Where much stone is to be handled in this manner, a hoisting engine is preferable to a snatch team, since an engineman at $2.50 and one-third of a ton of coal will do more work than a team even on short pulls, and far more on long pulls.

26 The steam for such a hoisting engine can usually be piped from the boiler that runs the rock crusher.

27. Steel channels can be laid up the hill, out of the pit, as a runway to make easy pulling.

28. Empty wagons going down the hill can pull the hoisting rope back. On a long hill it is often preferable to use a horse, driven by a boy, to pull the rope back.

29. On long hauls where there are steep hills, have your wagons and teams travel in pairs. Then the two teams can be hooked onto one wagon when a hill is encountered

30. Furnish each of your teamsters with a time card (such as is shown in Gillette's Handbook of Cost Data), so designed that the time of leaving the stone bin and the time of arrival at the place to dump the stone can be punched on the card with a conductor's punch. This gives such a complete record of the speed of travel and of the number of trips made, that every team is sure to do a full day's work.

31. In hiring teams, have an eye to the weight of the horses. A horse can exert a steady tractive pull for 10 hours equivalent to about one-tenth its own weight. A 1,200 lb horse will therefore exert a pull of 120 lbs all day long—although several times that amount for a short interval. A 1,600 lb horse will exert a steady pull of 160 stone for 3 cts per cu yd, if the stone horse There is also a marked difference in the speed at which different teams walk, which is well worthy of consideration in selected teams for hauling.

32 No team should ordinarily be used that will not haul at least 1½ cu yds on a poor earth road, and 3 cu yds over a macadam road

33. A steam roller makes a good traction engine for hauling wagons, but a roller is too busy rolling stone to do any hauling after the work of macadamizing has begun. If hauls are at all long, and if enough road work is in sight to warrant buying a traction engine, it will pay to haul the broken stone with an engine. Wagons made especially for traction engine hauling should then be used

34 The ordinary portable rock crusher can not crush stone fast enough to keep a traction engine busy on short hauls, hence the desirability of installing either two portable crushers or one large stationary crusher, where a traction engine is used

35 If, for any reason, it is necessary to crush the stone and store it in stock piles, use a clamshell bucket for subsequent loading of the stone into wagons. A laborer will shovel only 10 to 15 cu yds of broken stone from a stock pile into a wagon, whereas a clamshell and derrick will load stone for 3 cts. per cu. yd if the stone can be hauled away fast enough.

36. A steam roller rarely consolidates more than 50 cu. yds. of macadam (which is equivalent to 80 cu. yds. of loose stone and screenings) in a 10-hour day. Hence it is necessary to provide more than one roller if a clamshell bucket is to work to its full capacity. This feature of "balancing the plant" is frequently overlooked in estimating the costs of doing any particular part of the work by machinery.

37. In making stock piles of stone, where there is plenty of room, the best plan usually is to haul the stone away from the crusher bins in small side dump cars, building long piles of stone not very high, the rails being laid on top of the stock pile, and shifted laterally to widen the pile. When this is done, it is best to use a clamshell bucket mounted on a locomotive crane for loading the stone into wagons from the stock pile. Where the stock pile is not to be very large, a fixed derrick can be used to pile up the stone in a high conical pile, and subsequently the same derrick will serve to handle the clamshell bucket

Where a locomotive crane is used, a circular track can be built, so that the crane can deposit the stone in a conical pile in the center and also deposit in an annular ring outside the tracks. Then the same crane can handle the clamshell bucket for loading into wagons

38 Where broken stone is delivered in boats, a clamshell is unquestionably the most economic means of unloading. It is also economic in handling broken stone delivered in cars, unless the conditions are such that the cars can be dumped through a trestle into a stock pile, which is rarely possible on roadwork. If large quantities of stone are to be unloaded at one point, it may pay to erect a trestle, or to dig a pit, so that the cars can be dumped and the stone delivered onto an incline that will chute it off to one side where it can be picked up by a clamshell

39. If stone must be shoveled by hand from cars, see to it that it is shipped in flat cars, not in gondolas, for it is far easier to shovel from a flat floor

40 In loading wagons by hand from cars, always provide one or more extra wagons which can be loaded during the absence of the teams, for only a few men can work to advantage in car shoveling into a wagon and the process of loading is necessarily slow Therefore, to save team time, provide an extra wagon, unhitch the team from the empty wagon, immediately in the rear of the loaded wagon, fasten the tongue of the empty wagon to the rear of the loaded wagon, hitch the team to the loaded wagon and pull ahead far enough to bring the empty wagon opposite the men in the car, and unhook the empty This entire operation need consume only 1½ min, and is a great saver of team time

41 Load all wagons uniformly, and have wagons of uniform size This is essential in order to keep a careful record of the yardage of broken stone delivered on the road

42. In determining the average thickness of loose broken stone on the road, by far the most accurate method is to dump a given number of wagon loads of known size every "station" of 100 ft Any other method leads to dispute, for it is impossible to measure the thickness of loose broken stone accurately after it is dumped, and is also impracticable to ascertain the thickness of the rolled macadam with any great precision, particularly where the subgrade is at all yielding

Some specifications prescribe that small wooden blocks shall be placed on the roadbed at given intervals and that the loose broken stone shall be spread so that a straight edge laid on these wooden blocks will touch the top of the broken stone all along between the blocks This method has some merit, but, where the stone is spread with a machine of any kind, the wooden blocks are displaced, and the method of using such blocks becomes very objectionable. Since broken stone should always be spread by machines, for the sake of true economy, there is no thoroughly satisfactory way of determining the thickness of the loose broken stone, except by measuring or weighing the wagon loads and depositing them at calculated intervals

43. Dump the coarse broken stone directly on the subgrade, but dump the screenings or binder in piles on the earth shoulders of the road, whence it can be shoveled onto the rolled macadam at the proper time Some contractors make stock piles of the screenings near the crusher, haul it onto the road as needed and spread it on the rolled macadam directly from the wagon, using shovels for the purpose This involves three handlings, once from the bin to the stock pile, again from the stockpile to the wagon, and finally from the wagon to the road The last shoveling (from the wagon to the road) is particularly expensive for the screenings must be carefully spread, which takes time and holds the team and driver many unnecessary minutes each load

44 Never dump the coarse stone in piles on the shoulders of the road, to be afterward shoveled into the road It costs 15 cts. per cu. yd. to shovel the stone in this manner, even when wages are only 15 cts.

per hour. Some ancient history specifications still prescribe the dumping of the stone in piles on the side of the road or upon boards in the center, from which it is to be shoveled into the road. The originator of this fool specification is dead and his tombstone does not monument his folly. Whoever he was, he appears to have reasoned that wherever stone is dumped in a pile it is consolidated by its fall from the wagon, and, being so consolidated, there is more solid stone where the pile fell than in the adjacent areas where it has been shoveled by hand. And then he appears to have reasoned that this prevents an even distribution of the solid stone, unless all of it is spread by shoveling. To overcome this objection, spread all the stone with a machine, for the blade of the machine can readily move all the stone about and secure even density.

(The machines to be used for spreading will be described in the next of this series of articles).

Notes on State Highway Work in 1908

The following notes on highway work in 1908 in a number of states have been compiled from various state reports and from information furnished us by the state engineers or commissioners.

NEW CASTLE COUNTY, DELAWARE.

During the calendar years 1907 and 1908 a total of 53.81 miles of macadam roads were built in New Castle County, Delaware, at a cost of $376,279. The average cost per mile of these roads was $6,992. The average engineering expenses per mile was $122.01, and the average per mile for extra work was $192.09. The average width paved was 12 ft. although some roads were constructed with a stone bed of 16 ft. and in one case a section was constructed with a width of 9 ft. Granite was mainly used, although limestone was used in some cases.

The per cent of engineering expenses to the total cost was about 1.8 per cent. The accompanying table shows the averages per mile of total cost of engineering and extra work of roads built in New Castle County during 1907-1908.

ILLINOIS.

The Highway Commission of this state has an annual appropriation of $50,000, and this amount of money was expended during 1908 in road construction and supervision of bridge construction.

Thirty-five miles of macadam road were constructed in the state, using about 120,000 cu. yds. of stone, which were crushed by convict labor at the penitentiaries, and furnished free to road districts desiring to use the same.

Last season an experiment was tried on 1¼ miles of earth road, treated with asphalt, and the results indicated that this form of construction is practical. But considerable more work will have to be done before a standard method can be determined. Experiments were also tried the past season upon slag and gravel roads, treated with tar, and the same kind of road treated with asphalt. This form of construction is also quite promising.

AVERAGES PER MILE OF TOTAL COST, ENGINEERING AND EXTRA WORK, OF ROADS BUILT IN NEW CASTLE COUNTY, DURING THE YEARS 1907-1908.

Name of Road.	Material.	Width of stone bed, feet.	Depth of stone bed, feet.	Length in miles.	Cost of Road.		Engineering Expenses.		Extra Work.	
					Total.	Average per mile.	Total.	Average per mile.	Total.	Average per mile.
Foulk Road	.	..	.	1.24	$ 7,008	$5,652	$ 165	$133	$ 258	$208
Del'w'reCity to RedLionCreek	1	12	6	3.25	25,912	7,973	499	138	439	135
River Road	1	12	6	1.38	11,128	8,964	155	113	727	527
Summit Road	1	12	6	2.35	16,852	7,171	296	126	340	144
Telegraph Road	2	12	8	4.26	38,760	9,099	513	121	705	165
Mt. Pleasant to Boyd's Cor.	1	12	6	3.46	23,857	6,895	488	141	272	79
Depot & Telegraph Road	2	16	6	1.79	19,042	10,638	206	115	295	165
Depot Road (1st Sec.)	2	16	6	0.13	1,352	10,400	16	120	...	...
Depot Road (2d Sec.)	3	12	6	3.91	25,172	6,438	532	135	545	139
Christiana to Stanton	1	12	6	3.15	25,497	8,094	313	99	1,180	375
Wilmington to New Castle	4	14	8	2.64	23,249	8,807	348	132	1,563	592
Wilmington & Christiana Tp'k	5	16*	8†	3.72	29,486	7,926	607	163	1,144	308
Talleyville to Perkins Cor.	6	12	6	4.55	29,279	6,435	462	102	670	147
Lancaster Pike	5	16**	4††	2.91	29,476	10,129	256	88	675	232
State Road	7	12	6	3.29	20,363	6,189	268	81	604	184
Middletown to Maryland Line	7	12	8	3.11	18,298	5,883	324	104	468	151
T'yl'rsBrdg. to Flemings Ldg.	.	9***	4†††	4.70	4,547	967	800	170	113	24
Rogers Cross Road	1	14	8	0.67	4,781	7,136	63	94	51	76
Farnhurst to New Castle Rd.	8	12	8*†	1.24	6,776	5,464	94	76	131	106
Coopers Cross Road to McCannon's Church	2	12	8	1.17	8,853	7,566	94	81	114	97
Wilmington and Christiana Tp'k	8	16**	8*†	0.89	6,592	7,407	115	129	43	48
Totals and averages	.	..	.	53.81	$376,279	$6,993	$6,565	$122	$10,337	$192

*16 ft. for 2.2 miles; 12 ft. for 1.52 miles. †8 in. for 2.2 miles; 6 in. for 1.52 miles. **16 ft. to 12 ft. ††4 in. to 8 in. ***9 ft. and 12 ft †††4 in. more or less. *†8 in. and 6 in.

1 Brandywine granite. 2 Granite. 3 Cedar Hollow limestone. 4 Granite and limestone. 5 Granite and trap rock. 6 Native granite. 7 Limestone. 8 Granite bottom, limestone top.

MAINE.

During 1908 a total of 437,387 lin. ft. of roadwork was completed in this state at a cost of $264,583. The quantities and costs were as follows:

	Lin. ft.	
Macadam	50,004	$ 75,432.11
Tar macadam	846	2,797.30
Gravel	287,006	141,718.21
Block paving	1,461	9,453.78
Gravel and earth	10,863	5,419.94
Earth	87,207	29,761.77
Total	437,387	$264,583.11

The following table shows the cost per mile:

	Total miles built.	Av. width paved, about ft.	Av. thickness of complete pavement ins.	Av. cost per mile.
Gravel	54.36	20	8	$2,600
Macadam	9.50	20	6	7,940
Misc.	19.14			
Total	83			

The work was done by contract, the average unit price being as follows:

	Per sq.yd. Rolled in place.
Gravel	$0.21
Macadam	.50
Telford	.36
Tar macadam	.71
Block paving	1.60

The prevailing daily wages for common labor was $1.65; for two horse team and driver, $4.25. Nine hours constituted a working day.

About $8,000 was spent for engineering and inspection, of this sum $3,300 being for engineering. Engineering and inspection was about 3 per cent of the total cost of the roads, engineering alone being about 1.2 per cent. It is proposed to build about 100 miles of road this year.

MARYLAND.

The following roads were completed in 1908 under the direction of the Highway Division of the Maryland Geological Survey:

	Cost.
Macadam, 32 miles	$288,406
Shell, 0.57 mile	2,337
Sand clay, 1 mile	2,262

The cost per mile of this work is shown in the accompanying table:

	Total miles built.	Av. width paved ft.	Av. thickness of completed pavement ins.	Av. cost per mile.
Macadam	32	12 to 14	6 to 8	$9,012.67
Shell	0.57	9 to 12	9	4,100.02
Sand clay	1	18	6	2,262.32

The average unit prices for road work in 1908 were as follow: Gravel, $1.60 per cu. yd. rolled in place; macadam, 6 in. and 8 in. rolled in place, $4.20 per cu. yd., and $3.15 per ton; extra earth excavation, $0.65 per cu. yd. The prevailing daily wage per common labor was $1.45 per day, and $3.50 per day was paid for two horse teams and driver. The working day was 10 hours.

The Highway Division of the Maryland Geological Survey has for several years been investigating the matter of road preservatives and dust preventives, making elaborate analyses and tests in its laboratory, as well as watching the results obtained on the roads in other places. The division has done some work on its own roads with very satisfactory results, especially in the line of the "penetration process"—that is the method of saturating the macadam from the top with pitch compounds of various kinds, and believes that the success of this method is assured, under certain conditions at least, and that the main thing remaining to be accomplished is the proper standardizing of the pitch compound. The division is now at work on this problem.

MICHIGAN.

Since July 1, 1905, the total number of miles of road completed in this state has been as follows: Clay gravel, 1 mile; gravel, 155 miles; macadam, 166 miles. The total cost has been $1,002,000 including $250,000 paid in state reward.

The average cost of road work in 1908 was about as follows:

Gravel roads, $1,500 per mile for a 9 ft. paved width, 8 in. depth of completed pavement; macadam roads, $4,000 per mile for a 9 ft. paved width and 6 in. depth of completed pavement.

The State Highway Department does not have charge of road construction and only pays rewards on roads that are completed by local authorities in accordance with the specifications of the Highway Department.

MISSOURI.

The following data must be considered only as fairly close approximations. The State Highway Department records shows 51 special road districts in the state. There are 114 counties of which 101 complied with the Missouri laws of 1907 and appointed county highway engineers. Three months ago the State Highway Department sent blank forms upon which to make a return report to an official of each of the 51 districts, the 101 county engineers and to some county official in the counties without an engineer. Replies were received from 27 districts and 57 counties. Just one third of the districts and one-half of the counties. These were so well distributed over the state that the summary of the district reports received were trebled and that of the counties doubled in order to arrive at the total for the state. The data obtained from these reports are shown in the accompanying tabulation.

Macadam—	
Total miles of macadam roads	800
Miles of macadam roads constructed in 1908 ...	120
Public funds (money and labor) on macadam construction 1908	$298,000
Donations (cash) on macadam construction 1908	$21,000
Average cost per mile construction of 1908	$2,700
Gravel—	
Total miles of gravel roads	1,600
Miles gravel road constructed 1908	300
Public funds (money and labor) on gravel construction 1908	$258,000
Donations (cash) on gravel construction 1908	$60,000
Average cost per mile construction of 1908	$1,000
Earth (including all other than macadam and gravel)—	
Total miles of earth roads	103,000
Expenditure (money and labor) on earth roads 1908	$1,047,000
Average expenditure 1908 per mile of earth road	$9.80
Total Expenditures Upon Roads—	
Total miles of road	109,000
Miles of rock and gravel constructed in 1908	120
Public funds (money and labor) expended in 1908...	$1,573,000
Donations (cash) expended in 1908	$85,200
Total expenditures (money and labor) in 1908	$1,658,200
Percentage of donations to total expenditures	5.4%
Total Expenditures Upon Culverts—	
Total number of culverts (not including small pipe drains)...	89,000
Public funds (money and labor) expended in 1908	$163,400
Donations (cash) expended in 1908	$17,500
Total expenditures for construction in 1908	$180,900
Expenditures (money and labor) repairs and maintenance in 1908	$128,000
Total 1908	$308,900
Percentage of donations to total expenditures	5.6%
Percentage of expenditures for repairs and maintenance ...	41%
Total Expenditures Upon Bridges—	
Total number of bridges........	16,000
Public funds (money and labor) expended in 1908.............	$633,000
Donations (cash) expended in 1908	$37,000
Total expenditures for construction in 1908..............	$670,000
Expenditures (money and labor) repairs and maintenance in 1908	$133,000
Total 1908	$803,000
Percentage of donation to total expenditures	16%
Percentage of expenditures for repairs and maintenance	17%
Total expenditures culverts and bridges in 1908	$1,111,900
Grand Totals—	
Total miles of roads	109,000
Miles improved	5,100
Percentage of improved roads	5%
Total number of culverts	89,000
Total number of bridges	16,000
Total expenditures upon roads in 1908 ...	$1,658,200
Total expenditures upon culverts in 1908	$308,900
Total expenditures upon bridges in 1908 ..	$803,000
Grand total of expenditures, roads, culverts and bridges for 1908	$2,770,100
Percentage of grand total of expenditures for roads	60%
Percentage of grand total of expenditures for culverts and bridges	40%
Percentage of the above grand total expenditure in labor	10%
Average rate of poll tax	$3.00
Average levy for road tax (property) on the $100 of assessed valuation of property for 1908	$0.12

The labor donations, of which no record is made, is equal too if not greater than the cash donations. In some of the counties a large amount of the rock and gravel road work is done by labor donations. There being no record of this labor it reduces the apparent cost per mile of rock and gravel roads some little below the actual cost. Moreover a large number of these roads, especially the gravel, are second class roads, some of which are both narrow and second class, considering which the cost is not much below the average.

PENNSYLVANIA.

In this state 217 miles of road were completed in 1908, at a total cost of $2,200,000. The average cost per mile, inclusive of all bridges, culverts, etc., were as follows:

	Total miles built	Average width paved, feet	Average thickness of completed pavement, inches	Average cost per mile
Macadam,				
Telford	202	16	9	$10,000
Brick	15	16		$18,500

The average unit prices were as follows: Macadam per cu. yd. rolled in place, $3.75; telford per cu. yd. in place, $2.25; brick, $1.65 per sq. yd., on broken stone foundation; extra earth excavation, $0.52 per cu. yd.

Engineering and inspection was about 5 per cent of the total cost of the roads built in 1908. The total amount spent of engineering and inspection was about $110,000, of this amount about $11,000 was for inspection. The prevailing daily wages for common labor was $1.50, for two-horse team and driver, $1.50. A 10-hour day was worked.

NEW HAMPSHIRE.

A total of 71 miles of gravel and macadam roads were completed in this state in 1908. Of this total 55 miles were gravel roads costing $181,500 and 16 miles were macadam costing $108,000. The average cost per mile of these roads was as follows:

	Total miles built	Av. width paved ft.	Av. thickness of completed pavement ins.	Av. cost per mile
Gravel	55	15	8	$3,300
Macadam	16	15	6	$6,750

The average unit prices for road work

in 1908 were as follows: Gravel, per cu. yd. rolled in place $0.83; macadam per ton rolled in place $2.09; earth excavation, $0.52 per cu. yd. Other average contract prices taken from the report of the state engineer for the period Nov. 16, 1906, to Aug. 31, 1902, are as follows: Borrow, $0.66 per fu. yd.; ledge excavation, $2.40 per cu. yd.; concrete masonry, $8.88 per cu. yd.; dry masonry, $2.58 per cu. yd.; underdrain, $0.45 per lin. ft.; fencing $0.28 per lin. ft. The prevailing daily wages per common labor was $1.75 and for two-horse-teams and driver $4 to $4.50, a nine-hour day was worked.

Engineering and inspection was 2.9 per cent of the total cost of the roads built in 1908.

VERMONT.

About 63.50 miles of gravel roads and 36.37 miles of gravel telford roads were completed in this state in 1908, at a total cost of $241,795. About $6,000 was spent in engineering and inspection, about $1,500 of this sum being for engineering. The prevailing daily wages for common labor was $1.75, and two-horse teams and drivers received $3.50 to $4. The working day was 9 and 10 hours.

VIRGINIA.

The following table shows the average cost of roadwork completed in the state in 1908:

	Total miles built.	Average width paved, feet.	Average thickness of completed pavement, inches.	Average cost per mile.
Gravel ..	20.3	14	9	$1,543.60
Macadam ..	31.7	14	6	$4,476.11

The prevailing daily wages for common labor was $1; for two-horse team and driver, $3. The working day was 8 hours.

It is proposed to expend $700,000 this year for the construction of 50 miles of gravel roads and 125 miles of macadam.

Riverside Drive in New York City is to be extended from 155th St. to connect with the Hudson Memorial Bridge over Spuyten Duyvil Creek. The estimated cost of the work is $4,850,000, and bids are now being asked by the President of Manhattan Borough. The work includes the construction of a $2,000,000 viaduct. The drive will be 115 ft. wide, with a roadway, two sidewalks and a bridle path. The Inwood or Fulton viaduct, which will carry the extension over the Inwood valley, will be 100 ft. wide, 150 ft. high and 1,800 ft. in length. It will consist of three spans of 150 ft. each and six spans of 75 ft. The approaches will be of granite. The total length of the extension will be 3½ miles.

A total of 327.15 tons of explosives were used during January on the Isthmian Canal work.

Unclassified and General Articles

Note: This section is devoted to methods and cost articles on construction work not properly coming under any of the preceding classifications.

Method of Making Assessments for Drainage Districts.*

There are several theories advanced as to the way of reaching an equitable apportionment of the cost of construction that each tract of land should bear in a drainage district. Most of these possess merit, but all fall short of furnishing anything like a satisfactory rule in all cases. Different conditions are found in different districts, no two being alike, and when a formula attempts to meet all conditions, it becomes so complicated that it is not practicable and leads to confusion. While it is advisable and necessary to have some system, yet it is almost wholly a matter of judgment, and upon it will depend the equitable and proper distribution of the cost of the improvement.

Commissioners.—Men should be appointed for this work who have qualifications that fit them for it. They should be men who have some knowledge of drainage in general; who are good judges of land and who can distinguish at a glance, wet or low land from land that does not need drainage; men who can tell in a day season what lands are liable to be wet in a wet season.

Appoint such men as commissioners and it does not matter what system they use in arriving at their conclusions, they will not turn in an assessment roll until they are satisfied it is right, and if they have no system to begin with or if the system they have does not work out to their satisfaction, they will make one.

I shall not attempt to give any mathematical formula or plan for spreading assessment, but will try to deal with some of the conditions that arise and that must be intelligently met and solved by the commissioners in order to make an equitable assessment.

Time of Making Assessment.—The best time for spreading assessments is in the spring. During this time of the year the ground is free from vegetation, giving an unobstructed view of the surrounding land. In order to classify or judge a tract of land intelligently it is necessary to compare it with other tracts of land surrounding it, that is, its elevation as compared with other lands.

In the spring after the frost is out and after the heavy rains, is an ideal time for this work. When the corn and the other crops are high enough to obstruct the view, it is almost impossible to do satisfactory work. A few inches of snow on the ground also makes a very unsatisfactory condition for this work.

Plat and Water Shed.—The water shed should be taken as accurately as possible and shown on the plat, together with elevation at all low points on each 40-acre tract. The exact location of the ditch should be decided on and accurately shown on the plat before the assessment is made. If a radical change is made in the location of the ditch after the assessment is made, it will in most cases work an injustice to some one. A few days of extra work by the engineer in getting these details while laying out the district will be more than saved by the commissioners and will enable them to do better work.

Viewing the District.—It is a well established fact that the nearer a tract of land lies to a ditch the more benefit it receives and the farther away from the ditch it lies, the less benefit it receives. In viewing the land in the district, it becomes necessary to note not only the quality of each tract of land (which are usually 40-acre tracts), but also the distance to the ditch by its natural water course. For this purpose, each commissioner should carry a plat (a very light colored blue print is good for this purpose as it will show pencil marks). A good plan is to commence at the outlet and work up. This will enable the commissioners to trace every little water course and show on the plat at what point each tract of land gets its outlet into the ditch. It is not unusual to find land within a few rods of the ditch, while the water has to be carried a mile or more before getting into it.

All sub-divides should be marked, showing as near as possible what proportion of each tract sheds into the different draws or water courses. It is absolutely necessary to get these details in order to give the proper offsets for distance, from drain when making the assessment. Any other condition existing that would be taken into consideration should be made note of. A book or plat should, of course, be used for keeping a record of the quality of each tract, either by some system of classification, such as the number of acres of swamp, wet, low and high, or by some system of percentage or comparison.

After the commissioners have gone over the district, they should not only have the classification or quality of each tract, but should be able to recall every condition, either from memory or by referring to the plat of the whole district as well as each individual tract.

Occasionally, small swamps or ponds are found on land that lies high above the surrounding land and could be easily drained. Such ponds should not be treated the same as ponds on lower land without an outlet. A great many conditions are found which are very misleading, take, for instance the farm that is illy cared for and poorly farmed, a farm that is low and hard to work and gets too wet some seasons and the owner or tenant abandons part of it and lets it grow to weeds. Adjoining this land we find a farm that is just as low and as hard to work, but the owner manages to keep the weeds down and where his corn drowns out, he plows it up or sows it to millet or turnips and manages to raise something and keeps it looking better than it is. The farm that is not taken care of may be better than the other, yet it looks a great deal worse. Great care should be used in such cases. Even a good fence and other improvements have a tendency to improve the looks of a wet farm.

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*A paper presented at the Iowa Drainage Convention by H. M. Sparboe of Webster City, Iowa.

Another perplexing situation: Take, for example, two farms, one on each side of the drain; both farms low and full of ponds and wet places. On one of them shallow tile lines have been run with very little fall having submerged outlets at the low points on the farm, thereby relieving most of the farm of surface water and making some of it tillable. The other farm is still in its natural state; full of ponds and looks twice as wet as the other. The tendency is to assess the latter farm higher than the former. This is not right. We often hear men say: "My farm is tiled out and the drain will not benefit me any, but my neighbor, Jones has not a tile in his and he should bear the expense of the ditch." Now, Neighbor Jones should be given credit for all natural advantages and outlets he may have, whether he has taken advantage of them or not and should not be assessed more than the man who has put in some tile.

Computing the Assessment.—Nearly all drainage engineers and men who have made drainage a study, hold the land is benefited in proportion to its distance from a natural outlet, that is, land too near to the outlet should not be taxed as much as land similarly situated at the upper end of the drain. I do not believe this theory is right in all cases.

Where land lies back from the water course and is of sufficient elevation so as not to be affected by overflow from above and where tile can get a good clearance in times of high water, I think this theory is good. However, when a tract of low and flat land is situated in the water course and is subject to overflow from above, and where tile cannot get a clearance, I fail to see why this land does not receive as much benefit from the improvement as land at the upper end of the district.

It is argued that the land 80 or 100 rods above the outlet can be drained by a private drain, while the cost of draining a tract four or five miles above this would be prohibitive.

While this is true, yet the cost of putting in a drain of sufficient size to drain the land nearer to the outlet, and also take care of the natural flood waters from above, would be a great deal more, in most cases, than the assessment even if this land was assessed the same as land farther away from the outlet.

I believe that in cases of this kind where it is plain that a private drain would cost more than the joint drain—that is, this land's proportion of it—the assessment should be same as on similar land farther up the water course, as in both cases the benefits received are the same. Although it is a well established rule, and I think the law so states, that land should not be assessed for improvements above it, yet in such cases as have been mentioned, the land gets a direct benefit from the improvement above and should be assessed for such benefit.

Deep Digging.—Before proceeding to figure out the assessment, the commissioners should familiarize themselves with the profile of the drain. If it is found that parts of it are unusually deep, they should determine, either from information at hand or by consulting the engineer who planned the drain, why this extra depth was necessary, and the cost of this extra depth should be spread on the land for which it was made.

Branches Assessed Separately.—Where a district has a main line and several branches, it is often advisable to assess each branch by itself. This can be done either by spreading the cost of the main line over the whole district and then spreading the cost of the branch over the land which it serves, or by deciding first what proportion of the main line each branch, or the land draining into each branch, should pay, then adding the cost of the branch to it when the amount is spread as before.

Direct Drainage.—While the ditches and tile lines are put in primarily for outlet purposes, yet they furnish direct drainage to the land through which they go, and such land should be assessed for such drainage. If the drain goes through land that needs drainage, in addition to the outlet tax, it should be assessed, about the cost of a 6 or 8 inch tile line, unless it parallels a drain already in and working in which case it is questionable whether it should be assessed for such benefit.

Land Outside the Watershed.—Where land is taken into the district that properly belongs in another watershed, it may work a hardship on the district. To illustrate: Suppose a water shed contains about 620 acres of land, but at the upper end of the watershed is a quarter section which can be drained into the district by cutting through a small raise and it is included in the district. The size of the tile will have to be increased to the extent, that it will take care of 160 acres more. Now, if all but a portion of this quarter section is good land, and it is assessed on the same basis as other land in the district, it is possible that the assessment on the rest of the district will be higher than it would have been if this land is not taken in. This land should be assessed, at least, as much as the cost of the district was increased by taking it in, regardless of the quality of the land.

Where main lines have been put in and laterals are put in later to sub-districts, it is a good plan to have the same commissioners assess the sub-districts. They are somewhat familiar with the conditions and will, everything else being equal, make a more equitable assessment.

Where a large district is established, taking in smaller districts already established and assessed, and where a branch is run up to give the smaller district a better outlet, the cost of such branch, together with its share of the main line, should, with few exceptions, be spread in the same proportion as the tax was formerly spread on the district, excepting, of course, the amount spread on land between the main line and the district.

Railroads and Highways.—There have been a great many different opinions as to the methods of assessing railroad and public highways. It is one of the most perplexing problems that the commissioners have to deal with. Some have advocated that the assessment should be made on an acreage basis the same as farm land. Others have held that draining a swamp through which a railroad or public highway was built was of more benefit to the railroad or public highway than to the same amount of farm land.

An assessment made on the basis of the latter theory has been upheld by the supreme court in a case from Hamilton county.

Reviewing the District.—The commissioners should go over the district and make comparisons after figuring up the assessment. I know from experience that this plan is a good one. Conditions will be noticed that have been overlooked and will call for minor changes.

I sometimes think that if the commissioners were required to be present at the hearing, a great many things would be cleared up and a good deal of useless litigation avoided.

The commissioners should be able to give a good and logical reason for everything they have done, and if a man can be convinced that his land has not been assessed higher in proportion than his neighbor's he is usually at least like the Irishman who was licked—satisfied even if not contented.

At the end of 1907 the total length of the State Railways of Italy was 8,291 miles.

Track Laying on the Guymard Cutoff of the Erie R. R.

The Erie & Jersey R. R., better known as the Guymard cutoff, is a branch of the Erie R. R., and extends from Guymard, N. Y., to Turner, N. Y. It is a double track, low grade line, about 40 miles long, and for the present will be used for freight service. The grading of the line was done by contract, the following being the contractors: Bennett & Talbott, Otisville, N. Y.; Sundstrom & Stratton Co., New York City; Grant Rockafeller, Mountainville, N. Y.; Ferguson Contracting Co., New York City; Lathrop, Shea & Henwood Co., Campbell Hall, N. Y.; Clement-King Co., Land Title Bldg., Philadelphia, Pa.; Smith-McCormick Co., Easton, Pa.

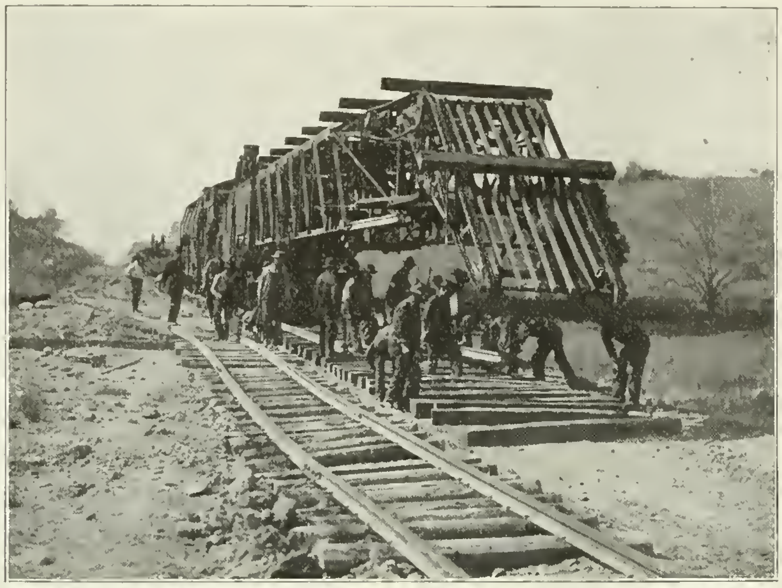

Fig. 1—End View of Track Laying Machine Showing Method of Depositing Ties.

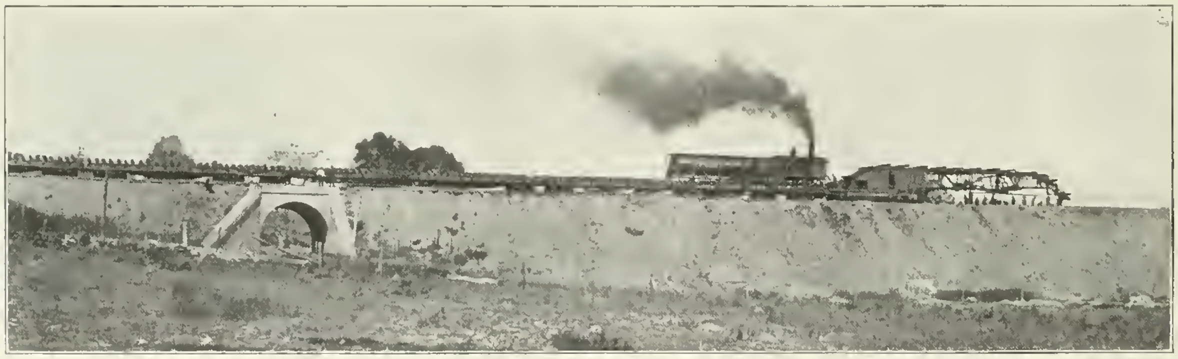

Fig. 2—View Showing Track Laying Machine in Operation on the Guymard Cut Off.

The tracklaying, however, was done by the railroad itself, and the accompanying illustrations show this portion of the work in progress. A Hurley tracklaying machine was used and the results obtained with the Hurley machine have attracted considerable attention among railroad men during the past few years, and especially so on the above mentioned work, where representatives of several railroads inspected its operation. One feature that is especially noteworthy is the fact that on the first half day's work, with the assistance of only 20 green Austrians, half a mile was laid and quarterspiked, which gives an idea of the labor-saving qualities of the machine.

The Hurley machine is entirely different from other tracklaying machines. In the first place, the machine is equipped with engines and a boiler which furnish power for propelling itself and a train of 20 to 30 cars of material along the track, as well as delivering the rails and ties on the roadbed at the front. The gearing is so arranged that the machine and train are moving constantly but very slowly, the speed being about 30 ft. per minute. As the machine handles the construction train, saving the cost of maintaining one locomotive and crew, it can readily be seen that there is considerable saving to the railroad or contractor.

A minimum amount of labor is required, as the material is brought up from the rear and delivered on the roadbed entirely by steam power. The ties are delivered to the machine itself by means of the rails which act as tie-conveyors. When the ties reach the machine they are picked up by an endless chain conveyor and carried over the truss to a point 68 ft. in advance of the car, where they are deposited on the roadbed and automatically spaced one at a time as the machine moves forward, as shown in Fig. 1.

On this machine trams for conveying the material are eliminated, as the rails are drawn forward on rollers over the material train by means of two sets (on each side) of powerful compression rollers and are taken ahead on the lower chord of the truss and lowered to position by means of steam hoists.

Fig. 3 shows one of the bents, or gallows frame, for handling the rails by

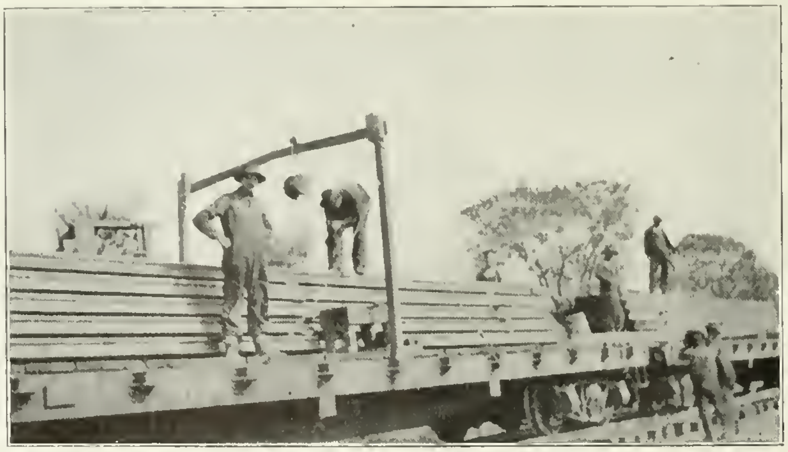

Fig. 3—Bents for Handling the Rails.

means of a Yale & Towne differential pulley and a trolley

The full tracklaying crew is composed of 40 men, which includes 8 spikers and 4 nippers. If there is a good organization, 3 or $3\frac{1}{2}$ miles per day can be laid and quarter-spiked. On occasions as much as 2,500 ft. per hour has been laid and quarter-spiked with this machine

From the foregoing it is apparent the Hurley tracklaying machine has made some wonderful records in regard to both speed and economy in laying track and is of especial benefit to contractors when they are bidding on a narrow margin of profit

The Hurley Track Laying Machine Co., Railway Exchange Bldg., Chicago, have some very interesting booklets fully describing their machines, also drawings showing in detail the construction and method of handling material which they will be glad to send to anyone desiring them.

Mr. C. K. Conard was Engineer in charge for the Erie R. R., and Mr. W. B. Taylor was Superintendent of Tracklaying

The best daily record of excavation on the Isthmian Canal for steam shovels since American occupation was made on Wednesday, Feb. 10, states the Canal Record, when 58 shovels in the Central Division removed 76,138 cu. yds. of material, an average of 1,318 cu. yds. per shovel. Of this amount, seven shovels in the Tabernilla District excavated 11,040 cu. yds., an average of 1,577 cu. yds. per shovel. The highest previous daily record was made on Feb. 5, when 56 shovels in the Central Division removed 73,412 cu. yds., an average of 1,311 cu. yds. per shovel. These shovels are under steam for eight hours per day, but are not actually at work during this entire period, time being lost by the necessity of moving the shovel forward, blasting stone too big for the shovels to handle, and keeping the shovels supplied with cars, etc. On Feb. 10, the 58 shovels were under steam a total of 464 shovel-hours and were actually digging 311.55 shovel hours. The 76,438 cu. yds. removed were loaded on 2,223 Lidgerwood flat cars, 264 large Western dump cars, and 2,749 small Western and Oliver dump cars, a total of 5,236 carloads. The material was transported an average distance of about 11 miles, and 411 train loads were dumped during the day

Building operations in 90 cities, as disclosed by the aggregate value of building permits granted during the month of January, $18,363,173, present a 96.7 per cent increase over the corresponding 1908 figures, though the total for January is below the total for the preceding month

The average daily number of laborers employed on actual construction work on the Isthmian Canal during January was 31,078.

Some Notes on Rail Bending.

BY RALPH H. SEIPPY *

The following table is a record of the performance of a section gang of 10 men and their foreman in the work of bending rails under the writer's inspection in 1902

The rails, Am. Soc. C. E. 72-lb. section, 30 ft. long, were distributed along the track ready to be laid. Where the ground was level enough to permit, the bender was moved ahead for each pair of rails. However, since the bender required a clear and comparatively level space of about 15 ft. in diameter, it was usually necessary to choose a suitable location for the bender on each curve, gather the rails up on a push car and after bending to redistribute them.

The bender was of the ordinary Jim Crow type. The curvature of the rails was tested by means of a template 12 ft. long which consisted of a straight edge, iron shod at the ends and having heavy wood screws at the one-quarter and one-half points. The screws were adjusted to the length of the ordinates of the curve required, by means of a screw driver. Several trials were usually necessary on the first rails of each curve to determine the position of the movable wheel of the bender which would give the desired curve. When this position was found the bender was marked with chalk so that it could be tightened to the same point for the rest of the rails of that curve. This resulted in a fair degree of uniformity of bending except on the 18° curve. On this the power was not sufficient to move the bender and the rails were run through the bender twice

A heavy fall of snow and the frosty weather interfered with the work to some extent on account of the slipperiness of the rails and the poor foothold for the men.

LABOR RECORD OF RAIL BENDING, 1902.

Date		No. of Curve	Degree of Curve	No. Bent
Nov. 19.	A. M.	1	1	16
	....	2	6	2
	P. M.	2	6	8
		3	8	12
Total				38
Nov. 20.	A. M.	3	8	4
	....	4	18	8
	P. M.	4	18	12
		5	10° 10'	3
Total				27
Nov. 21.	A. M.	5	10° 10'	19
	P. M.	5	10° 10'	16
Total				35
Nov. 22.	A. M.	5	10° 10'	12
	P. M.	6	4	16
Total				28
Nov. 23.	A. M.	7	5	21
	P. M....	7	5	18
Total				39

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*102 So. Romine St., Urbana, Ill.

Estimated Unit and Total Costs of Railway Track Elevation at Wilkes-Barre, Pa.

The railways entering the city of Wilkes-Barre, Pa., have in conjunction with the city officials adopted a plan for track elevation and the general elimination of grade crossings in that city. These plans were worked out under the direction of a board of engineers composed of the City Engineer of Wilkes-Barre and one engineer appointed by each of the railways concerned. This board employed A. D. Chidsey, Jr., Easton, Pa., to take charge of surveys, plans and estimates under its direction. Three plans were worked out and one of them known as plan E, was adopted. From the report of the Board of Engineers recently made public, we take the following general description of the proposed work and, which is of more interest, a very complete and careful estimate of the cost of the construction work

One six track through line, for both passenger and freight movements, is provided; the alignment following very closely the present line of the Central Railroad of New Jersey. The junction of the steam roads is effected opposite the South Wilkes-Barre breaker and at South Wilkes-Barre, and opposite the Lehigh Valley Railroad round house at North Wilkes-Barre. A direct connection with the Plymouth branch of the Delaware & Hudson Co. is provided, crossing South Main st. on an overhead structure

In the city block between Market and Northampton streets and Baltimore st. and Pennsylvania ave., the union station together with the requisite service building, power plant, platforms and passenger tracks, is shown.

A yard to provide the necessary coach and engine storage, coal, ash, water and inspection facilities is provided just north of Scott street.

All the various industrial connections are maintained.

The present viaduct of the Wilkes-Barre & Hazleton Ry. Co. is to be abandoned and removed. The Wilkes-Barre & Hazleton Ry., at or near Welles st., will curve to the left, paralleling the through line of the steam roads, crossing Market st. overhead, and reaching a terminal provided for their use on Baltimore st. A physical connection is provided with the steam roads and a baggage and passenger tunnel connects their passenger platform with the union station

The terminal of the Lackawanna & Wyoming Valley Railroad is not altered, and the trains of this road are not brought into the union station neither is any covered passageway leading to the union station provided

The route of the Lackawanna & Wyoming Valley Railway through the city is entirely changed. The proposed route leaves the present tracks of this company at or near Prospect breaker, north of the city, crosses a branch of the Central Railroad of New Jersey, and the main line of the Lehigh Valley Railroad overhead; then parallels the Lehigh Valley Railroad main line to Conyngham avenue, occupies the present right of way of the Lehigh Valley Railroad to Jackson street, from which point the connection is made with their present terminal.

For the operation of the steam roads a joint management or a terminal company to operate the joint tracks and yards will be necessary.

The local freight facilities can be placed under the control of the individual companies or operated as a joint freight terminal.

The grade crossings on the following lines are included in the general elimination scheme. The main lines of the Lehigh Valley Railroad Central Railroad of New Jersey, Delaware & Hudson Company and Pennsylvania Railroad, the Plymouth branch and Conyngham branch of the Delaware & Hudson Company, the South Wilkes-Barre yard of the Central Railroad of New Jersey, and under scheme "E," the main line of the Lackawanna & Wyoming Valley Railroad.

The elimination of grade crossings is accomplished by a general elevation of all the railroads from South Wilkes-Barre to Scott st. The Pennsylvania Railroad, however, will be required to start their elevation at Buttonwood, about 1¼ miles out of the city limits. A general elevation for top of rail of 551 Wilkes-Barre city datum is used from South Wilkes-Barre to South st. From Northampton st. to a point near Scott st. the elevation is taken at 553 Wilkes-Barre city datum. On scheme "E" the grade along the present line of the Central road of New Jersey is raised, starting from a point in the proposed elevation, opposite the Hollenback breaker, to a point opposite the Lehigh Valley Railroad round house. The grade of 0.32 per cent is ascending in a northward direction. This grade was decided upon to avoid depressing Scott st. as much as possible.

A typical plan for a subway street under crossing was adopted. This plan shows a railroad bridge spanning a 60 ft. street with two 19-ft. driveways and two 80-ft. sidewalks; it was deemed advisable to widen the street and place columns along the center of the street. The bridge is to be of concrete-steel construction. The steel in the span is designed to carry the entire load, but is imbedded in concrete as a protection to the steel and to provide a solid waterproof, noiseless floor. The standard under clearance for the street roadway to be from 12 to 14 ft., according to local condition.

All subways as proposed can be drained into the existing sewers.

Under the schemes presented the treatment of the various streets at the railroad

ESTIMATE, SCHEME "E."

(Approximate.)

Embankment—		
2,022,000 cu. yds. at 40c		$ 808,000
Track—		
Main line, 115,200 lin. ft. at $2.50	$288,000	
Sidings, 199,200 lin. ft. at $1.75	348,600	
Turnouts, 206 at $250.00	51,500	
Crossing frogs, 5 at $500	2,500	
Interlocking	80,000	770,600
Retaining walls—		
Concrete, 25,700 cu. yds. at $8	205,000	
Concrete, 15,700 cu. yds. at $7	109,900	
Excavation, 17,500 cu. yds. at 50c	8,500	
Hand rail, 10,600 lin. ft. at $1.50	15,900	
Drain pipe, 150 tons at $40	6,000	345,900
Bridges—		
Carey avenue, Hanover Township	26,000	
Division street	23,000	
Barney street	32,500	
South Main street	34,600	
South Main street (D. & H.)	12,000	
Blackman street	3,000	
Wood street	10,800	
Dana street	89,500	
Hazle street	58,500	
South street	129,000	
Northampton street	43,000	
Market street	87,000	
Scott street	74,000	
Conyngham avenue highway bridge ($80,000).		
Conyngham avenue undergrade	115,800	
North Pennsylvania avenue	51,700	814,700
Freight yard and houses—		
Paving, 63,800 sq. yds., at $2.50	159,500	
Freight houses, 15,000 sq. ft. at $2.50	37,500	
Platforms, 52,000 sq. ft. at 85c	44,200	
Drainage	11,300	252,500
Raising P. R. R. engine terminal		30,000
Canal culvert—		
Raising 75 manholes at $60		4,500
Union station—		
Power house	15,750	
Power plant	50,000	
Express building	17,500	
Wilkes-Barre & Hazleton Railway shelter	15,000	
Passenger station	350,000	
Station shed, steps, fixing grounds, etc	50,000	
Subway, 650 lin. ft. at $100	65,000	
Platforms, 76,000 sq. ft. at 25c	19,000	
Platform sheds, 4,000 lin. ft. at $10	40,000	622,250
Streets—paving, grading—		
Division street	3,000	
Barney street	3,500	
Proposed street	16,500	
South Main street	11,500	
South Main street (D. & H.)	4,000	
Hanover street	5,000	
Blackman street	7,500	
Proposed street	11,100	
Wood street	9,500	
Dana street	23,750	
Hazle street	16,200	
Northampton street	13,500	
Baltimore street	14,500	
Market street	22,000	
Scott street	23,000	
Conyngham avenue	58,000	
Pennsylvania avenue	42,500	285,050
Wilkes-Barre & Wyoming Valley Traction Co.—		
Changes in tracks		27,250
Wilkes-Barre & Hazleton Railway—		
3,000 ft. of lin. track at $3.50		10,500
Engine terminal—		
Engine house, 24 stalls	60,000	
Coal and ash facilities	160,000	
Water supply	30,000	250,000
		$4,222,050
General, legal, engineering and incidental expenses, about 15 per cent		637,950
Total, main line construction		$4,860,000
Salvage—		
4 400 tons of rails at $15	$ 66,000	
250 turnouts at $100	25,000	
W.-B & H. Ry. Co. viaduct, 1,100 tons at $10	11,000	

Note—The item of salvage is assumed to offset the cost of maintaining traffic during construction.

PROPERTY.

The value of property required for the development of scheme "E" is given at double the valuation placed on the same by the city assessors.

Required for railroad purposes		$ 986,200
Required for widening streets, bridge approaches, proposed streets, etc		146,000
		$1,132,200
Consequential property damages—		
South Main street	$ 8,000	
Hanover street	5,000	
Wood street	8,000	
Blackman street	3,000	
Dana street	16,500	
Hazle street	8,250	
Northampton street	6,000	
Scott street	7,000	
Conyngham avenue	10,000	71,750
Total main line property and damage		$1,203,950

Note—The above estimate covers the damage to property adjacent to the improvements, but does not cover the damage to the public due to the closing and changing of streets.

South Wilkes-Barre Yard, C. R. R. of N. J.
Construction.

Embankment—		
75,000 cu. yds. at 40c		$ 30,000
Track—		
10,500 lin. ft. at $1.75	$ 18,375	
Six turnouts at $250	1,500	19,875
Retaining wall—		
Concrete, 2,440 cu. yds. at $8	19,520	
Concrete, 1,340 cu. yds. at $7	9,380	
Excavation, 1,500 cu. yds. at 50c.	750	
Hand rail, 2,400 lin. ft. at $1.50	3,600	
Drain pipe, five tons at $40	200	33,450
Bridges—		
South Main street	17,300	
Hanover street	7,200	
Wood street	15,000	
Walnut street	13,500	53,000
Streets—		
Wood street	2,500	
Walnut street	2,500	5,000
		$141,325
General, legal, engineering and incidental expenses, about 15 per cent.		$ 21,175
Total		$162,500
Property (At double assessed valuation)—		
Required for side slope		$28,000

Note. The main line estimate includes the elevation of this branch from the L. V. R. R. to Carey avenue. This estimate covers the approximate additional cost of elevating from the L. V. R. R. to the Susquehanna river.

Plymouth Branch, D. & H. C.
Construction.

Embankment—		
243,000 cu. yds. at 40c		$ 97,200
Track—		
13,172 lin. ft. at $1.75	$ 23,050	
Turnouts, 7 at $250	1,750	24,800
Bridges—		
Carey avenue	14,600	
Old River Road	17,600	
Raising three high water channel bridges	35,000	67,200
Streets—		
Carey avenue		2,600
		$191,800
Legal, general engineering and incidental expenses, about 15 per cent		28,700
Total		$220,500
Property (At double assessed valuation)		40,0000

L. & W. V. R. R. Co., Change of Route
Construction.

Embankment—		
Cut 43,300 cu. yds. at 40c	$17,320	
Cut 18,600 cu. yds. at $1.00	18,600	
Borrow 21,000 cu. yds. at 40c	8,400	44,320
Track—		
22,600 lin. ft. at $3.50	79,100	
Raising W.-B. & E. R. R.	8,000	87,100
Bridges—		
C. R. R. of N. J. branch	36,000	
L. V. R. R. main line	41,000	
W.-B. & E. R. R.	18,000	
Mill Creek	28,000	
North Main street	50,000	
North Washington street	19,000	
Pennsylvania avenue	18,000	210,000
Streets—Paving, grading, etc.		
Proposed street		25,000
		$366,420
General, legal, engineering and incidental expenses, about 15 per cent		53,580
Total		$420,000
Property (At double assessed value)		31,000

SUMMARY.

Main line—	
Construction	$1,860,000
Property and damages	1,203,950
South Wilkes-Barre yard, C. R. R. of N. J.—	
Construction	162,500
Property and damages	28,000
Plymouth Branch, D. & H. Co.	
Construction	220,500
Property and damages	40,000
L. & W. V. R. R., change of route—	
Construction	420,000
Property and damages	31,000
Grand total	$6,968,950

crossings throughout the city will be as follows:

Lehigh Valley Railroad.

Blackman street—Raise present overhead bridge 4 ft.

Parrish street—Build subway, raise tracks 10 ft., depress street 8 ft.

Hazle avenue—Build subway, raise track 10.8 ft., depress street 7.2 ft.

South street—Build new overhead highway bridge.

Northampton street—Build subway, raise track 10.75 ft., depress street 7.25 ft.

Market street—Build subway, raise track 7.25 ft., depress street 10.75 ft.

Jackson street—To be vacated.

Scott street—Present subway remains.

Hortense street—Build foot bridge.

Conyngham avenue—Build overhead highway bridge.

Pennsylvania avenue—Build subway, depress street 18 ft.

Washington street—Present overhead highway bridge remains.

North Main street—Build highway bridge.

Central Railroad Co. of New Jersey.

Blackman street—Raise present overhead highway bridge 4 ft.

Parrish street—To be vacated.

Dana street—Build subway, raise track 12.2 ft., depress street 5.8 ft.

Hazle avenue—Build subway, raise track 16.2 ft., depress street 1.3 ft.

Lehigh street—To be vacated.

South street—Build new overhead highway bridge.

Northampton street—Build subway, raise track 10.2 ft., depress street 7.8 ft.

Market street—Build subway, raise track 10.8 ft., depress street 7.2 ft.

Scott street—Build subway, raise track 7.7 ft., depress street 10.3 ft.

Hortense street—Build foot bridge.

Conyngham avenue—Build overhead highway bridge.

South Main street—Build subway, raise track 12 ft., depress street 6 ft.

Hanover street—Build subway, raise track 12 ft., depress street 6 ft.

Wood street—Build subway, raise track 18 ft.

Walnut street—Build subway, raise track 15 ft., depress street 1 ft.

Delaware & Hudson Company.

Scott street—Build subway, raise track 7.7 ft., depress street 10.03 ft.

Hortense street—Build foot bridge.

Conyngham avenue—Build overhead highway bridge.

North Pennsylvania avenue—Build subway, depress street 18 ft.

South Main street—Build subway, raise track 17 ft., depress street 1 ft.

Hanover street—Track removed from street.

Wood street—Build subway, raise track 17 ft., depress street 1 ft.

Carey avenue—Build subway, raise track 15 ft., depress street 3 ft.

Old River road—Build subway, raise track 18 ft.

Pennsylvania Railroad.

Carey avenue road, Hanover township—Build overhead railroad bridge.

Division street—Build subway, raise tracks 17 ft., depress street 1 ft.

Horton street—To be vacated.

Barney street—Build subway, raise track 17 ft., depress street 1 ft.

Franklin street—To be vacated.

South Main street—Build subway, raise track 12 ft., depress street 6 ft.

Dana street—Build subway, raise track 10 ft., depress street 8 ft.

Hazle street—Build subway, raise track 10.8 ft., depress street 7.2 ft.

South street—Build new overhead highway bridge.

Northampton street—Build subway, raise track 10.75 ft., depress street 7.25 ft.

During the last ten years the Russian Government has spent $911,510,000 in increasing the efficiency of the railways and constructing new lines.

Estimated Costs of a Cantilever Bridge and of a Suspension Bridge Across the St. Lawrence.

In 1896 the Montreal Bridge Co. received competitive plans and estimates for a proposed bridge across the St. Lawrence river at Montreal. The bridge was specified to be one channel span of 1,250 ft., two side spans of 500 ft. each, 15 steel viaduct spans on south approach of 250 ft. each, 18 viaduct spans on north approach of 60 to 240 ft. each, the clear headway in the channel span to be 150 ft. The bridge was to be for a double track steam railway, two street railway tracks, a carriageway and two sidewalks. The piers of the cantilever were to be of masonry.

The prize plan was submitted by Edward S. Shaw of Boston. He increased the side spans to 600 ft. The bridge was designed to be 80 ft. wide, with four trusses. The stone sub-piers are each 30x110 ft. in plan on top, 60 ft. above low water, surmounted by steel piers 230 ft. high. The middle roadway is 26 ft. wide and is for the double track railway; the two side roadways are each 21½ ft. wide; flanked by 6 ft. sidewalks on brackets. The estimated weight of structural steel was:

	Lbs.
Main cantilever and central span	39,460,000
South viaduct approach	26,340,000
North viaduct approach	8,200,000
Total	74,000,000
Estimated cost of superstructure	$3,514,000

This is about 4¾ cts. per lb. It would appear from one of the estimates made by another competitor that custom's duty of 1 ct. per lb. of steel ready for erection would be required.

A suspension bridge design was submitted by Mr. C. C. Wentworth, M. Am. Soc. C. E. It was to be a stiffened suspension bridge of 1,300 ft. span, with two 500 ft. side spans supported from the cables, giving a total length of 2,300 ft. There were to be 4 cables, each of 17½ ins. diameter. The two stiffening trusses were to be 52 ft. apart on the clear, leaving the roadway for the railway and electric lines. The carriageways and sidewalks were to be on brackets outside the trusses.

The estimated cost was as follows:

11,000,000 lbs. riveted steel center span, at 4.25 cts.	$ 467,500
20,000,000 lbs. steel in towers, side spans and anchorage, at 3½ cts	700,000
30,000,000 lbs. steel in viaduct spans and towers, at 3 cts.	900,000
8,000,000 lbs. wire in cables, at 6 cts	180,000
Copper covering on cables	20,000
Timber floors and ties	81,000
600 tons steel rails	18,000
Hand railing	25,000
60,000 cu. yds. anchorage masonry	360,000
Total for superstructure and anchorage	$3,051,500

It will be noted that if the same unit prices for steel had been assumed in both styles of bridge, the cost would have been more nearly equal, although about 7 per cent less for the suspension bridge.

Personals.

Mr. A. F. McCallum has been appointed City Engineer of Hamilton, Ont., succeeding Mr. E. G. Barrow, who has been retained as Consulting Engineer.

Mr. Archibald O. Powell has opened an office in the Central Bldg., Seattle Wash., where he will engage in a consulting engineering practice.

Mr. L. H. Long has been appointed Chief Engineer of the Gila Valley, Globe & Northern Ry. to succeed Mr. E. A. McFarland, who resigned some time ago.

J. N. H. Cornell & Co., Engineers and Contractors, will on March 15 move from their present offices at 29 Broadway, New York, to new offices at 60 Wall St., that city.

Mr. Charles M. Spofford, Professor of Civil Engineering at the Polytechnic Institute, Brooklyn, N. Y., has been appointed Hayward Professor of Civil Enginering at the Massachusetts Institute of Technology, succeeding Mr. George F. Swain, resigned.

Mr. F. M. Emerson, for some time connected with the contracting department of the American Bridge Co., has formed a company to be known as F. M. Emerson & Co., and will engage in a contracting business. The headquarters of the company will be in Milwaukee, Wis.

Mr. A. B. Shepherd has resigned his position as Acting Director of the Department of Public Works of Pittsburg, Pa. Mr. Shepherd is Superintendent of the Bureau of Water of that city and will devote the greater part of his time to the reconstruction of the South Side water system.

Mr. C. A. Crane has opened offices at 13 Park Row, New York, for the practice of civil engineering, in connection with the secretaryship of the General Contractors' Association. His present office in The Bronx, at 505 East Tremont Ave., New York, will be conducted as heretofore, in conjunction with the down town office.

Mr. M. P. Paret has resigned as Chief Engineer of the Kansas City, Mexico & Orient Ry. and has entered into a partnership with E. J. Beard, Chief Engineer of Philippine Railway Construction, for practice as consulting engineers. Mr. Walter Colpitts succeeds Mr. Paret as Chief Engineer of the Kansas City, Mexico & Orient Ry.

Messrs. Benjamin F. Abbott and J. P. Howells have entered into a partnership and will engage in an engineering practice with offices in the People's Bank Bldg., Wilkes-Barre, Pa. Mr. Howells has for some time been Consulting Engineer with the Lehigh & Wilkes-Barre Coal Co., while Mr. Abbott was formerly on one of the Lehigh Valley Coal Co.'s engineer corps, but has for some years been with the American Smelting Co. of the Guggenheim interests in the South.

The following changes in officers of the Corps of Engineers have been ordered by the U. S. War Department:

Capt. William P. Stokey is relieved from duty at Havana and from the command of Company G, Second Battalion of Engineers, and will proceed to Savannah and report to Col. Don C. Kingman for duty.

Capt. Alfred B. Putnam is relieved from duty under the immediate orders of Maj. William W. Harts and will proceed April 5 to the Washington Barracks, District of Columbia, for duty with the Second Battalion of Engineers.

First Lieut. Ralph T. Ward is relieved from duty with Company A, First Battalion of Engineers, to take effect upon arrival at Honolulu of Company G, Second Battalion of Engineers, and will then report to Maj. E. Eveleth Winslow for duty with Company G, Second Battalion of Engineers.

Maj. E. Eveleth Winslow will assume command of the Second Battalion of Engineers upon arrival at Honolulu of the headquarters and Company G of that battalion will relinquish command of the First Battalion of Engineers upon the departure from Honolulu of the headquarters and Company A of the latter battalion.

Second Lieut. Lewis H. Watkins is relieved from duty with Company B, First Battalion of Engineers, and will proceed to San Francisco and report to the commanding officer, Company G, Second Battalion of Engineers, for duty, and will proceed with that company to Honolulu on the transport to sail from San Francisco on May 5.

Catalogs Worth Having.

Engineers and contractors should have on file the latest catalogs of machines, tools and supplies that they use. In sending for catalogs reviewed or advertised in this paper, you will confer a favor on us if you will write direct to the advertisers and state that you saw the catalog mentioned in ENGINEERING-CONTRACTING. If you are in the market for tools, machinery or supplies, tell us and we will notify promptly the leading manufacturers.

No. 1120. **Water Towers.** — Des Moines Bridge & Iron Co., Des Moines, Iowa.

Illustrates a variety of styles of steel water towers and gives dimensions and capacities of standard tanks. Tables of capacity of pumps, horsepower required to raise water different heights, fire streams, friction in pipes, etc., are given.

No. 1121. **Corrugated Metal Culverts.**—The Canton Culvert Co., Canton, O.

Folder 108 of this company gives some very interesting data regarding sectional corrugated metal culverts. This culvert is shipped knocked down and nested and has several other special features worthy of study. Tables of sizes, etc., are given.

No. 1122. **Bar, Mesh and Fabric Reinforcement.**—The General Fireproofing Co., Youngstown, O.

A handsome 48-page pamphlet describing and illustrating this company's square lug bar, cold twisted lug bar, herring-bone trussed bar expanded metal and wire fabric reinforcement. Valuable slab tables are given for lug bar, expanded metal, and wire fabric reinforcement. The tables make this catalog of value to keep on file.

No. 1123. **A Review of Concrete Chimneys.**—The Weber Co., Chicago, Ill.

Describes the development of concrete chimney construction as practiced by the company named and gives an account and a defense of the failure of two concrete chimneys of the company's type. A very interesting pamphlet.

No. 1124. **Steel Bound Concrete Curb.**—Steel Protected Concrete Co., Philadelphia, Pa.

A pamphlet describing the construction and merits of steel bound concrete curb and one pamphlet of unusual value giving full detailed directions for constructing such curb. The last pamphlet is one worth keeping permanently on file. The company also has a desk ruler and paper weight souvenir which will be mailed free to interested engineers.

No. 1125. **Smith Mixer.**—The T. L. Smith Co., Chicago, Ill.

This is a very handsome catalog and is also a descriptive catalog of real merit. The mixer and its accessories are described and illustrated in full detail. This catalog should be secured and kept on file.

No. 1126. **Air Compressor.** — Ingersoll-Rand Co., 11 Broadway, New York.

A 64-page catalog devoted to a description of this company's Class "H" type of air and gas compressors, which is a duplex steam driven machine.

No. 1127. **Correspondence Schools.**—American School of Correspondence, Chicago, Ill.

Bulletin issued by this well known school outlining the various courses in engineering that are taught by text books and correspondence.

No. 1128. **Earth Handling and Road Building.**—Russell Grader Mfg. Co., 25th and University Ave., Minneapolis, Minn.

A 24-page pamphlet describing elevating graders in the disc plows and a gasoline engine for operating the conveyor; various kinds of road machines, plows and scrapers of all kinds are described.

No. 1129. **Monolith Steel Bars.**—Monolith Steel Co., Washington, D. C.

A 50-page pamphlet showing application of monolith bar to beam, slab and column reinforcing. Some 36 pages are devoted to a discussion of design of reinforced concrete with formulas and methods for calculating girders and columns, and beam and slab tables. A useful catalog to have on file.

No. 1130. **Owl Cement.**—German-American Portland Cement Works, Chicago, Ill.

This pamphlet will be found of value for the standard specifications and for the very complete directions for testing and using cement and concrete for a variety of structures.

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The Advantage of the Bonus System and Suggestions to Contractors Who Contemplate Applying It.

In our last issue, the last sentence of an article on a method of driving a tunnel is this: "A system of bonus payments for rapid advance greatly helped in attaining above results."

This is recorded one more successful application of the bonus system. So many scores of instances of this sort have been published within the last few years that the wonder is that the bonus system has not become universal, instead of remaining the exceptional method of paying workmen. Conservatism and skepticism control the actions of men to such a degree that any new machine or method must face a long fight before it is extensively adopted, and this in spite of self-evident merits.

To the man of self-reliance and of keenness in perceiving the economic merit of a new method, this very conservatism on the part of other men offers a splendid chance to outstrip competitors. Among all the new methods of doing work, none possesses more obvious merit than the bonus system. We call it a new method, yet it has been in use for many years in shop work. Its newness is largely confined to such fields of production as contracting. Many a contractor today does not even know what the bonus system means.

The bonus system requires the payment of a regular daily wage plus a bonus for each unit of work done in excess of a stipulated minimum. Thus, a driller receives a $3 wage and a bonus of 5 cts. per lin. ft. for each foot of hole drilled in excess of a stipulated minimum of, say, 60 ft. per day. If the wages of the driller and his helper, and the cost of power, of repairs to drill, etc., amount to $9 a day, it costs 15 cts. per lin. ft. of drill hole when only 60 ft. are drilled. Hence there is a decided gain to the contractor on every foot of hole for which he pays only 5 cts. in the form of a bonus.

So effective is the bonus system as a stimulus to both the wits and energy of a worker that no contractor who has given it a good trial will ever abandon it willingly. Neither will the workman abandon it, unless the contractor unfairly increases the minimum of work required, or cuts the bonus. The bonus system is a money maker for all concerned.

Since many of the old school of contractors have not adopted the bonus system, and show no intention of doing so, a splendid opportunity is offered to younger men who put it into operation on their own contracts. A few suggestions to such young men may be of assistance in starting them along a road to a larger income and to possible wealth.

First, survey the field of work in your neighborhood to ascertain what classes of construction are mostly handled according to the old slave driving methods of management. Select the field in which your competitors are followers of the old school. They are slave-drivers that have not learned that one can do work with greater economy under the bonus system. In the first place remember that the slave-driving method requires a boss or driver to every 10 to 20 workmen. His wages are 50 per cent more than the wages of each man that he supervises, and if he is supervising 15 men, the wages of this "boss" will amount to 10 per cent of the total wages paid to these 15 men. Hence, if you can dispense with this boss by adopting the bonus system, you will save 10 per cent of the labor cost of doing the work, and this is about the average of what can be accomplished on small jobs. It is true that the bonus system itself requires supervisors to apply it, but one supervisor can handle several times as many men as can a boss, or he can handle a few men with less of his own time, and thus be free to perform other duties.

On contract work there is much more difficulty in applying the bonus system than there is in shop work, which accounts in part for the fact that few contractors have adopted it. In shop work, men usually work as individuals, or as small gangs of 2, 3 or 4 men. On contract work in the field, men more often work in large gangs. Hence the difficulty of paying them according to their individual achievements. Then, again, it is frequently difficult to measure the work done each day in the field. These very difficulties, however, make the game more fascinating to the contractor who enters into it. These difficulties deter the man who lacks wit or perseverance, and therefore they reduce the amount of effective competition, for most men are lacking either in perseverance or ingenuity.

To illustrate how some of the difficulties can be overcome, let us take an example. Suppose the work consists in shoveling earth into wagons, and that 12 men are engaged, 6 men to a wagon. It is possible, of course, to pay this entire gang a bonus on every wagon in excess of, say, 100 wagons loaded per day. This will stimulate them, but it may lead to bickering, for the ablest shovelers are apt to berate those that can or will not attain a high speed. Clearly it is preferable to split this gang into smaller units if possible, but how? Two men will delay the team if no others assist them in loading. Six to each wagon is none too many, when lost team time is taken into account. But why not eliminate this element of team time? In most cases it can be done, by the simple expedient of providing a few extra wagons, and unhitching a team from the empty wagon with which it returns and hitching it to the full wagon. When this is done two men may be assigned to each wagon.

Can we not go a step farther? Is there no way of determining exactly what each of these two is performing? There is

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Place a vertical partition across the middle of each wagon box, and let each man shovel into his half of the wagon. A time keeper can then give each workman a ticket, or punch his output card, and thus record the exact output of every individual.

This example illustrates the ease with which a seemingly difficult problem in applying the bonus system is solved, and it also illustrates the necessity of studying methods commonly used with a view to modifying them sufficiently to permit ascertaining how much work each individual performs. There is pleasure in solving problems of this sort, and there is profit to double the pleasure.

There are many classes of field work that must necessarily be performed by a gang of men working in such a manner that individual output can not be ascertained from observation of their work as a gang. In such cases, it is well to ascertain the energy of the individuals by putting them all at some sort of uniform work, such as boring holes through timbers, simply for the purpose of trying the men out. Give the men their regular wages plus a bonus, and it will take only a few days to find out who are the real workers. Weed out the poorer men and substitute others until a gang is secured which is practically *uniform* as to the physical strength and willingness of the individuals composing it. Such a gang engaged, for example, on pile driving, can then be offered a bonus to be distributed equally among the gang. Being composed entirely of active, willing men, there is small likelihood that serious trouble will arise among the members of the gang. On the other hand, a few incompetents or drones will quickly breed such discontent in a gang working as a unit under the bonus system that the system will be a failure.

Our two conclusions are: First, give careful thought to possible methods of doing work, so as to substitute individual work for gang work. Second, if gang work must be done, select the gang with as much care as a baseball team is selected, eliminating all drones, dullards or weaklings.

Application has been made to the New York State Public Service Commission for a franchise for an "inter-terminal belt line" in New York City, entirely within the Borough of Manhattan, a modification of a more extensive system of freight subways submitted to the Commission some months ago by W. J. Wilgus, president of the Amsterdam Corporation, of 165 Broadway, New York. The proposed system consists of a four-track water front belt line, elevated in some places and underground in others, with a crosstown line at 59th street and lines connecting with the Grand Central and Pennsylvania passenger terminals.

Concrete and Reinforced Concrete Section

Note:—This section is devoted to methods and cost of constructing concrete and reinforced concrete structures. It will cover the selection, testing and proportioning of concrete materials; laboratory tests of concrete; concrete mixing, transportation and placing; fabrication and placing of reinforcement, and form construction and erection. It will also contain articles on new and interesting developments in the design of reinforced concrete.

Comparative Construction and Maintenance Costs of Reinforced Concrete and Steel Bridges.*

BY E. P. GOODRICH.†

In a discussion on the subject of reinforced concrete arches and other structures at the annual convention of the American Society of Civil Engineers, June 26, 1906, two almost opposite opinions were expressed with regard to the relative costs of structural steel and of reinforced concrete for bridges. Mr. R. S. Buck, while acknowledging "his limited experience with the system," in his opening remarks, stated that the development of reinforced concrete work.**

> has been largely in the hands of contractors and contracting engineers, with whom a vital point has been to bring it in competition with all-steel construction. In this, the speaker inclines to think, there has been rather an unfortunate disposition to reduce the cost unduly at the sacrifice of certainty, stability and durability. It is not possible to construct a steel-concrete arch that will compare in cost with an all-steel bridge and at the same time furnish the desired characteristics to be reasonably looked for in a masonry arch. The steel-concrete bridge possesses sufficient merits, the speaker believes, when designed on conservative lines, to often reduce the question of first cost to a minor position; and if it cannot do this it is a good form of bridge to let alone.

The opposite idea was conservatively expressed by Mr. J. R. Worcester, as follows:‡

> One statement by Mr. Buck, if correctly understood, that there could be no comparison between the cost of steel-concrete bridges and steel bridges, seems to the speaker to be true only when one factor—that is, the cost of the abutments for the steel bridges—is left out of consideration. The speaker's experience is that, in the case of a highway bridge of moderate span, a comparison between a steel-concrete bridge and one of steel with buckle-plate floor filled on top will show that the steel-concrete bridge is considerably cheaper, and that where good foundations are easily obtained, if the total cost of bridge and abutments is included in the comparison, there is a fair chance for steel-concrete construction to compete with all steel.

Between these two views there is sure to be a middle ground of fact, the boundaries of which may, however, be difficult to define, but after nearly ten years of phenomenal development in concrete construction some added experience has thrown additional light on the subject.

At the quarterly meeting of the Association of American Portland Cement Manufacturers, held in Philadelphia, April 10, 1907, Mr. George S. Webster discussed the subject of "Concrete Bridges." In it he described briefly the Walnut Lane Bridge in Philadelphia. In answer to an inquiry, he said:*

> The contract price for the bridge was $262,000. A steel bridge would probably cost less in this location; a stone bridge approximately 50 per cent more. The aditional cost of this bridge over one of steel is due to the cost of centering. As the bridge is located in Fairmount Park and over the picturesque Wissahickon Creek, a steel bridge would be inappropriate with the surroundings.

In this case it is to be observed that no real competition took place between those advocating concrete and those who exploit steel bridges. A decision was reached requiring the construction of concrete and the first cost was of rather secondary consideration. And that has come to be the general attitude of those associated with the selection of types of bridges for given sites much more than was the case eight or ten years ago. At that time alternate bids were often asked for steel bridges and also for concrete arch construction. Among many such cases the following may be cited, wherein the reinforced concrete design carried an estimated cheaper first cost:

(a) A seven-span bridge of concrete at Waterloo, Iowa, cost $54,000, or $1.80 per sq. ft., while the lowest bid for a plate girder construction was higher.

(b) A seven-span bridge of concrete at Dayton, Ohio, cost $123,170. Eight bids were received for a steel plate girder design and seven on the concrete-steel design. The latter were about $10,000 the lowest.

(c) A 120-foot span concrete bridge at Lansing, Mich., cost $31,000, while the lowest of the three steel bids was $35,000.

(d) While not strictly a competition, it is to be noted that with regard to the Sandy Hill 15-span concrete bridge, which cost $77,000, Prof. William H. Burr, in a letter to the writer, says: "I am very sure that a steel bridge to carry the same loads could not have been built for much, if any, less cost than the reinforced concrete structure."

(e) A cheap but substantial highway bridge in Wabash County, Ind., which was guaranteed flood proof, cost $573 in competition with steel bridges and plain concrete culverts of same span and roadway, the lowest bid on steel being $665 and on plain concrete $943.

(f) The Illinois Central Railroad erected a bridge over the Big Muddy River for the following approximate amounts:

Work for railroad company	$ 34,402
Work by contractor	72,128
Skeleton steel	4,451
Crushed stone	7,200
Engineering, etc	6,700
	$124,881

This may be compared with the cost of enlarging or rebuilding the original piers and abutments and placing thereon a superstructure of three double-track steel spans built to carry the present standard loading, estimated as follows:

Masonry	$ 30,000
False work	10,000
Shop work at 3.58 cents	75,180
Erection and painting	10,500
	$125,680

(g) At Yorktown, Ind., was erected a 95-ft. span highway bridge for about $100 less than the lowest bid for a steel truss bridge of the same span. The construction was completed and the bridge thrown open for traffic in only a little more than 60 days after the award of the contract.

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*A paper read before the National Cement Users' Association, Cleveland convention, Jan. 13-16, 1909.

†Consulting engineer, New York, N. Y.

**Trans. Am. Soc. C. E., vol. XLVI, p. 95.

‡Op. cit., p. 101.

*Bulletin No. 15, Assoc. Am. Port. Cem. Mfrs., p. 11.

On the other hand steel often is of less first cost than concrete.

(a) In the case of the Junction Hollow Bridge in Schenley Park, Pittsburg, a concrete arch estimated to cost $7 per sq. ft., is described as "only a trifle more than was paid for the steel arch which was accepted and built."

(b) At Stockbridge a small foot bridge over the Housatonic, if built of iron, was estimated to cost $1,475, while the concrete one actually erected cost more than that figure, because of bad foundations.

(c) The competitive plans prepared for the memorial bridge over the Potomac, for the chief engineer of the army, included several different designs in concrete. It is said that a steel structure for the same site would have cost about 33 per cent less than that of the winning design in reinforced concrete.

TABLE I.—DIMENSIONS AND COSTS OF CONCRETE ARCH BRIDGES.

Place	Over	Total Length Bridge	Arch Spans	Width	Rise of Arch	Total Cost	Cost per sq. ft.	Date Erected
Pine Road, Philadelphia	Pennypack Creek		2a 25'4½"	34'3½"	6'6"	$ 8,662	$4.94	1893
Neuhansel, Hungary	Neutra		6a 55'9½"	19'8"	3'8½"	13,700	2.00	1893
Munderkingen Wurtemburg	Danube		164'0"	26'3"	16'5"	21,420	4.50	1894
Richmond Av., Syracuse	Harbor Brook		12'0"	49'0"	2'6"	2,000	3.40	1894
Eden Park, Cincinnati	Park Ave		70'0"	32'0"	10'0"	7,130	3.15	1895
Stockbridge	Housatonic		100'0"	7'6"	10'0"	1,475	2.00	1895
Belleville, Ill.	Richmond Creek		40'0"	52'0"	7'0"	10,500	3.90	1895
Topeka	Kansas River	693'0"	5a 125'0" 2a 110'0" 2a 97'6"	40'0"		125,000	4.50	1896
Inzigkofen	Danube		141'0"	12'0"	14'4"	6,650	3.70	1896
Immau	Eyach		98'5"	13'1"	9'10"	4,285	3.30	1898
Green and Goat Islands	Niagara	371'0" 198'0"	2a 103'6" 1a 110'0" 2a 50'6" 1a 55'0"	40'0"		102,070	4.50	1900
Indianapolis	Fall Creek.		6a 74'0"	65'0"	9'6"	105,340	3.70	1900
Juana Diaz, Porto Rico	Jacaguas River	404'0"	1a 120'0" 2a 100'0"	18'0"	12'0" 11'3"	59,438	8.15	1900
Juana Diaz, Porto Rico	Guayo River	270'0"	3a 70'0"		7'6" 7'0"	25,683	5.25	1900
Worthington.	Piney Branch		24'0"	26'0"	5'0"	3,170	5.10	1900
	Quarry Road		80'0"	28'6"	14'0"	21,500	9.40	1900
Chatellerault, France	Vienne	143'0"	164'0"	26'3"	15'0"	35,000	3.00	1901
Washington	Rock Creek		80'0"	27'0"	15'0"	17,500	8.10	1901
Wabash Co., Ind.			25'0"	16'0"		573	1.45	1902
Forest Park, St. Louis	River des Peres		45'0"	45'0"		10,600	5.20	1902
Liabach, Austria	Liabach		109'4"	50'0"	14'4"	30,000	5.60	1901
I. C. R. R.	Big Muddy River	483'0"	3a 140'0"	34'2"	30'0"	125,000	7.60	1901-3
Plainwell, Mich.	Kalamazoo River	446'0"	7a 54'0"	25'0"	8'0"	19,900	1.80	1903
Saley St., Brooklyn	Prospect Ave	125'0"	85'0"	60'0"		21,800	4.30	19
Munich	Grunwald	720'0"	2a 230'0"	30'0"	42'0"	65,000	3.10	1904
Connecticut Ave., Washington		1,341'0"	2a 82'0" 5a 150'0"	52'0"	41'0" 75'0"	850,000	12.20	1905
16th St., Washington	Piney Branch	272'0"	125'0"	25'0"	39'0"	42,731	6.25	1905
Dayton	Great Miami.	588'0"	69'0"-88'0"	56'0"		123,170	3.70	1904
Park Ave., Newark	Branch Brook Pk	243'7"	132'0"	74'0"	10'2"	84,000	4.70	1905
Connington, Viaduct		600'0"	10a 50'0"	16'0"	16'0"	52,200	5.43	1903
Greensburg, Ind.	Clifty Creek		80'0"	16'0"	12'0"	2,695	2.10	
Wayne St., Peru	Wabash River	500'0"	6a 75'to100	30'0"	15'0"	36,900	2.46	
Wabash, Ind.	Charley Creek		2a 75'0"	30'0"	18'0"	7,000	1.56	
Pollaskey		800'0"	10a 75'0"	18'0"	11'0"	48,000	3.33	
Meridian Street		250'0"	3a 74'0"	60'0"	9'0"	51,000	2.26	
E. Wash'n St., Indianapolis			65'0"	57'0"	10'0"	10,885	2.94	
Muncie, Ind.			38'0"	16'0"	7'6"	640	1.21	
Bangor, Me.		90'0"	46'7½" 38'2"	40'0"	8'7" 7'6"	6,500	1.80	
Mieres, Spain		333'0"	3a 34'4" 2a 114'4"	23'app		30,300	3.90	
Skodsbury, Denmark			71'6"	10'0"		2,000	2.80	
Sandy Hill		1,025'0"	15a 60'0"	35'8"		72,000	2.00	
Walnut Lane, Philadelphia		585'0"	233'0"	60'0"		262,000	7.50	
Emperor Bridge Sarajeno			115'10"	40'0"	12'0"	16,500	12.00	
Maryborough, Queensl'nd		613'0"	a 80'0"	22'8"	4'0"	75,000	5.40	
Lansing, Mich.	Grand River		120'0"	52'10"	23'0"	31,000	4.90	

(d) In the competition for a bridge at Plainwell, Mich., 23 proposals were submitted for different types of steel bridges, varying in price from $14,000 to $26,000, all the leading builders in the country being represented. For concrete-steel construction six bids were received, ranging from $16,000 to $27,000. The board favored a concrete bridge, but the only bid within the appropriation ($20,000) was rejected on account of faulty design. At an adjourned letting, three bids were received for concrete-steel, varying from $19,900 to $20,500.

Some other comparisons in first cost may also be instructive.

(a) For a bridge over the Neutra at Neuhansel, in Hungary, a concrete bridge consisting of six spans, each 55.8 ft. in the clear, cost $13,700, while a wooden one of twelve spans was estimated to cost $12,000.

(b) The concrete arch over Park avenue, in Eden Park, Cincinnati, cost $7,130, while a stone structure was estimated at $12,000.

(c) At Belleville, Ill., for a bridge over Richmond Creek, plans were prepared for bridges of iron, stone, brick and concrete. Bids were received on the last two named only and ranged between $11,259 and $12,839 for a brick arch and between $10,473 and $12,110 for concrete.

(d) At Indianapolis, the lowest price received for building two Melan bridges was $105,340, the lowest price for stone bridges being $140,996. Steel bridges, although somewhat lower in cost than the concrete ones, were rejected on account of their inferior beauty and their temporary character.

In an interview with Mr. Edwin Thatcher, the Nestor of concrete bridge builders of the United States, he stated that concrete could almost always compete with steel for highway structures whenever the floor in each case was to be paved like the street surface. When, however, a plank floor was allowed in the case of the steel structures, concrete could not usually compete successfully, simply on the basis of first cost. Concrete has not been used to any great extent in railroad work except for spans so short as to class the structure as a culvert. The Florida East Coast Railway is a case, however, where many miles of concrete arch viaduct were erected and steel structures were not considered, the writer is told. Other railroads are also taking up this class of construction more and more as time passes and it will doubtless soon be recognized as a special type of construction [illegible] and other purposes.

Mr. George P. Carver, in his hand book on Reinforced Concrete, gives detailed estimates of concrete arch bridges of 50, 75 and 100 ft. span 28 ft. wide, from which he has prepared a curve of costs to be used in roughly estimating such structures for interurban railroad use.

The estimates are as follows:

SPAN, 50 FT.; WIDTH, 28 FT.

Steel, 27,700 lbs., at 2½ cents	$ 692.50
Steel placing, 27,700 lbs., at 1 cent	277.00
Formwork at $1 per cu. yd	370.00
Cement, 481 bbls., at $2	962.00
Sand, 185 cu. yds., at $1	185.00
Stone, 370 cu. yds., at $2	740.00
Mixing and placing 370 cu. yds. at $1.50	555.00
	$3,781.50
Incidentals add 15 per cent	567.22
	$4,348.72
Profit add 10 per cent	434.87
	$ 4,783.59

SPAN, 75 FT.; WIDTH, 28 FT.

Steel, 38,800 lbs., at 2½ cents	$ 970.00
Placing steel, 38,800 lbs., at 1 cent	388.00
Formwork at $1 per cu. yd	740.00
Cement, 962 bbls., at $2	1,924.00
Sand, 370 cu. yds., at $1	370.00
Stone, 740 cu. yds., at $2	1,480.00
Mixing and placing 740 cu. yds. at $1.50	1,110.00
	$6,982.00
Incidentals add 15 per cent	1,047.30
	$8,029.30
Profit add 10 per cent.	802.93
	$8,832.23

SPAN, 100 FT.; WIDTH, 28 FT.

Steel, 55,650 lbs., at 2½ cents	$ 1,391.25
Placing steel, 55,650 lbs., at 1 cent	556.50
Formwork at $1 per cu. yd	1,008.00
Cement, 1,310 bbls., at $2	2,620.00
Sand, 504 cu. yds., at $1	504.00
Stone, 1,008 cu. yds., at $2	2,016.00
Mixing and placing 1,008 cu. yds. at $1.50	1,512.00
	$9,607.75
Incidentals add 15 per cent	1,441.16
	$11,048.91
Profit add 10 per cent	1,104.89
	$12,153.80

Table I gives some of the dimensions and costs of a number of arches. In the case of single arch spans, the cost per square foot is computed from face to face of abutments and out to out of railings.

Continental European practice is well described by Prof. Morsch in "Eisenbetonbau." Translations of the pertinent parts of this book are as follows:

In the early stages of railroad construction culverts roofed with natural stone were extensively employed. With the advent of concrete and of cement pipe, arched conduits, easily constructed in concrete, or, for smaller openings, concrete pipes were substituted. With the introduction of reinforced concrete, however, slab culverts again became useful. Since it is possible with the aid of reinforcement to make the concrete slab resist any bending stress, the span of the slab on the clear way through these culverts can be increased to about 6.5 m. (21 ft.), so that their field of usefulness has been greatly extended. The span might be still further increased, but beyond about 5 m. (16 ft.) T beams are cheaper than simple slabs. The usual arrangement is (then) to span the opening with several similar parallel girders and lay a floor slab between them. T-beam bridges of this type of spans up to 16 m. (52 ft.), are entirely practicable and in most cases cheaper than steel bridges. Special instances exist of 20 m. (66 ft.) spans. With wider spans the girders become rather heavy, so that T beam bridges possess little superiority over steel ones.

An important advantage of such reinforced concrete bridges over railways is that they are not affected by the gases from the locomotives, which, in the case of busy stretches of track and where difficult of ac-

> cess, cause active corrosion and high maintenance charges for steel structures. . . . If the length of a horizontal reinforced concrete bridge is greater than 16 to 20 m. (43 to 66 ft.), intermediate supports must be provided. . . .
>
> In straight girder bridges of greater lengths an expansion joint must be provided about every fourth opening. . . .
>
> In arched bridges, reinforced concrete can be employed either for the arch alone or the superstructure, including the roadway, or in all structural parts. . . .
>
> In medium spans of 40 to 50 m. (130 to 165 ft.), the employment of reinforced concrete as the arch material is less frequent, since in this case, provided a proper profile has been employed, no tensile stresses occur because of the large dead load. On the other hand, reinforced concrete is better adapted for long spans. If the safe compressive stress in the arch is not to be exceeded, it is necessary to limit the weight of the superstructure, and this can be done by a suitable employment of reinforced concrete. In this way the dead load stresses will be greatly reduced, but the small edge stress may decrease to zero or change to tension under unfavorable live loads, so that the reinforcement is again necessary.
>
> In consequence, where it is desired in small and medium spans that no tensile stresses shall exist, or, in other words, where only mass concrete work is employed, the superstructure cannot be kept too light. A light superstructure is then justifiable only when demanded for architectural reasons or when it is necessary to impose as little weight as possible on the foundations. . . .
>
> The arches can be constructed as restrained or as three hinged by using suitable material. . . .

A large number of examples are given of each type of construction mentioned. Among them are included the three-hinged arch in Grunwold over the Isar. It is 220 m. (772 ft.) long, including two main spans of 70 m. (230 ft.), with a rise of 12.8 m. (42 ft.). The floor has a width of 8 m. (26.2 ft.) between rails Prof. Morsch (who was also the designer) finally remarks:

> Since the actual cost of the bridge was only about 260,000 m. ($62,000 approximately), it is demonstrated, as far as the Grunwold-Isar bridge is concerned, that arched bridges with a proper arrangement of reinforced concrete and of large span, can compete successfully with steel construction.

In this connection it should be noted that such published lump costs as appear from time to time in the technical magazines, should not necessarily be interpreted as the actual construction costs of the work, unless the contractor is known to be one of long experience in bridge erection. The governing bodies of municipalities, counties, companies, etc., are altogether too prone to accept the lowest bid in a competition, irrespective of the qualifications of the bidder. Many inexperienced men have submitted figures on work which they were unable to compass, when put to the actual test, often losing heavily but being compelled for business reasons to shoulder the loss and say nothing. In other and rarer cases, the work has suffered to a dangerous degree and the municipality or other body for which the bridge was erected has lost much more through costs of repairs, than the difference between the lowest actual and the lowest responsible bid. Such bodies will usually save money in the long run by retaining the services of one of the several expert concrete engineers now to be found in this country, who will either prepare a single design upon which all bidders can base their figures, or prepare specifications calling for detailed designs accompanying each bid, with the privilege retained of accepting any bid which is considered as best meeting the requirements of the case. A waiver should also be exacted of each bidder, concerning any claim whatsoever for himself or any other if his bid is not accepted.

All the costs contained in Table I are first costs, or the initial expenditure, which is almost invariably financed by an issue of bonds by the municipality, township, or corporation undertaking the erection of the structure. These bonds usually carry about four per cent interest and run for a period of from twenty to fifty years, provision for their retirement being made by the establishment of a sinking fund in which is placed a small yearly percentage raised by taxation or derived from income. The gross amount of these two annual obligations thus usually amounts to between six and ten per cent of the cost of the structure. This condition is the same, irrespective of its type, the only point being the reduction of this yearly expenditure to a minimum by cutting down the first cost as much as possible and extending the life of the bonds as much as advisable so as to reduce the annual amortization charge. Obviously, the bond period should not extend over a greater period than the life of the structure.

The question then immediately arises as to the probable relative and actual lives of various types of bridges. Stone arch bridges have been in existence from the times of antiquity, but the advocates of steel structures will say "they were not built of concrete." In the south of France is a concrete arch bridge known as the Pont du Gard which was erected in the year 56 B. C. The concrete in this was not composed of crushed stone or other small aggregate of the variety now employed in concrete bridge work, but was of the old style, consisting of alternate layers of large and small stones, gravel, etc., and of cementitious materials. Vitruvius describes the materials and methods in use before the Christian era and other writers like Alberti in 1485 and Polladio in 1570 accurately describe the method which "the ancients" (as they call them) employed, "of using boards laid on edge and filling the space between with cement and all sorts of small and large stones mingled together." It is very improbable that the Pont du Gard would have withstood the rigors of climate of the Northern United States, but its actual state of preservation, as well as that of many other specimens of ancient concrete work, proves that if modern work is honestly executed, it will many times outlast any reasonable bond period, so that a very small yearly sinking fund per cent is all that is required for properly designed and erected concrete work.

Fr. von Emperger, in a paper read before the American Society of Civil Engineers in April, 1894, writes as follows:

> It is not out of place to remember that quite a number of concrete structures, in addition to the Roman water conduits, have stood through centuries, as, for instance, the cross-arched vaulting (78 ft. span) over the bath of Diocletian, in "Hexædra amplissima," and the parabolic main aisle of St. Peter's (87 ft. span and 150 ft. rise), both in Rome.
>
> Speaking of modern structures, the writer may mention the bridge over the Isere, France (span, 85 ft.; rise, 8.5 ft., and 2.5 ft. thickness in crown); the bridges over the Saevale and the Iregua near Torio, Spain (spans, 33 ft.; rise, 7.5 ft., and 3 ft. thickness in crown), and the aqueduct at Vannes, France, built in 1868-69. . . .
>
> In the latter the arches have 75 and 125 ft. span. Later on, the Pont d'Alma and Pont Napoleon were built as railway viaducts near Paris, spans about 140 ft. and one-tenth rise. Another more recent example (1873) is a bridge of 105 ft. span, 13 ft. rise and 20 ins. thickness at the apex, near Erlach, Germany.

In the photograph of the Aqueduct of Vejus reproduced in that paper, the characteristic appearance of concrete is visible at many points.

To steel or wooden structures, on the other hand, only a relatively short life can be assigned at best. Wood will be dismissed without further comment, except to remark that, in some parts of the west where wood is exceedingly cheap and where steel and cement can be obtained only after being transported very long distances, so that their costs are very high (from the heavy freight rates made necessary), it may be possible that wooden structures involve the smallest yearly charge, in spite of their very short life, even when treated with creosote or other preservatives.

Turning to steel then as the only real competitor of concrete, a remark ascribed to the late George S. Morison is often repeated, that

> Steel bridges are built to last fifty years, but they do usually last hardly half that time.

This condition is due to insufficient or entire absence of maintenance. The writer has been told of one highway bridge in Wisconsin which had to be replaced after only eight years of service. Of course this is an exceptional case. Steel bridges over railroad tracks where locomotive gases can produce their full destructive effect, have been known to last just about the same period. Morsch cites an example of a girder erected in 1886 and found with its web entirely eaten away at many points, in 1907.

In a paper read by Prof C. M. Spofford and Mr. F. H. Fay, Dec. 16, 1908, before the Boston Society of Civil Engineers, the Boylston St. bridge over the Boston and Albany R. R. tracks in Boston is described and its history recounted. It was originally erected in 1888, with small clearance between the floor system and the locomotive stacks. It was subject to almost constant train service, and except for the top chords, was practically built anew in 1908. In the new structure, all floor beams, etc., were protected with concrete, while the bottom chords were raised above the level of the floor planking, which thus protects them.

Where highway bridges are properly maintained, even when subjected to the action of locomotive gases, they have been known to last much nearer the theoretical limit assigned them by Mr. Morison than this one last cited. On the New York Central R. R. are several which were erected as long ago as 1868, 1874, 1875, 1875, 1876, 1876, 1877, 1881, 1881, etc. These figures in each case give the actual dates of erection of special structures. The great total and almost steady yearly increase in weight in railroad rolling stock during the past twenty years has made it necessary for practically all of the older roads to rebuild and strengthen their track structures, so that little real information is obtainable as to the possible life of a steel bridge. With careful inspection and maintenance there is really no reason why a well constructed steel bridge should not last indefinitely, and such structures as Brooklyn Bridge (built in 1884, for example), or the Niagara Arches, may be expected to see many generations.

In the "Technograph" of the University of Illinois, for 1893, Mr. Albert F. Robinson, Engineer of Bridges and Buildings of the C., R. I. & P. Ry., states the principle that the life of steel railroad bridges is only fifteen years because they must all be rebuilt to accommodate heavier traffic at intervals of about that length. Mr. G. W. Kittredge, Chief Engineer of the New York Central system, stated to the writer that they had practically rebuilt all the bridges on their system during the past few years commencing in 1900, but that while those in the list mentioned above had largely been strengthened, the old portions were still in excellent condition. He stated further, that when the Grand Central Station train shed was removed this year, it was found in remarkably perfect condition. It was erected in 1870, of wrought iron imported from England. The Cincinnati and Southern Railway was built about 1880, and the bridges along its line were constructed in an especially substantial manner and in accordance with specifications which were then considered as particularly advanced. Nevertheless, about 1900 it became absolutely essential to rebuild them and the past five years has seen a gradual reconstruction throughout the whole system. Again in this instance the twenty-year interval is apparent as the maximum period for special bridge bonds, if they were to be issued.

A conservative deduction from the above mentioned, and many other observations, would lead to the conclusion that ordinary highway bridges should not be assigned an average life exceeding twenty years at most, and fifteen would be a really better period to which to limit the life of steel highway bridge bonds. Railroad bridges usually receive better care, and their life may be considered as somewhat longer, except that from time to time they must be strengthened in order to make them safe for increased loads.

Mr. Robinson, in the paper cited above, presents estimates of the costs of strengthening single track structures of different lengths, assumed to have been erected about 1882 in accordance with the standard specifications of the Erie Railroad, issued about 1879 and so rebuilt as to conform to the standard specifications of the Lehigh Valley Railroad, prepared in 1892. In condensed form they are as follows:

Length in Feet	Cost in 1882	Cost of Strengthening in [illegible]	Per Cent
40	$ 901.10	$ 377.27	41.1
50	1,344.20	[illegible]	43.0
60	1,816.20	713.50	39.2
80	3,136.20	1,408.1	45.0
100	4,739.00	1,925.50	42.0
120	6,018.00	2,857.30	47.0
140	7,792.28	3,573.90	46.0
160	9,924.70	4,388.30	44.0
180	11,679.00	5,158.50	44.0

These figures reveal the average percentage of cost of renewal to be 43.6. This is in addition to the regular maintenance costs and is equivalent to about 3 per cent per annum, corresponding to a life of about thirty-five years for the original structure, computed on this purely theoretical basis.

In discussing this subject it is very difficult to separate the annual depreciation from the maintenance costs. Lumping all such items together, the New York Central assumes 5 per cent per annum as the amount on which to base all maintenance and depreciation charges when contracting with municipalities concerning railroad and highway crossing structures. Since this figure is to cover all charges of whatsoever kind, it is necessary to assign somewhat more than this figure or about thirty years as the assumed life of the bridge and thus a somewhat arbitrary but fairly satisfactory rate of depreciation can be assumed for all steel bridges. On this basis, at least 5 per cent should always be assumed as the yearly amortization rate for such structures, against not to exceed 2 per cent, corresponding with a bond period of fifty years, for concrete ones, irrespective of first cost.

Turning now to the subject of maintenance, pure and simple, nothing has yet been written better than the Preliminary Report of the Committee on Iron and Steel Structures of the American Railway Engineering and Maintenance of Way Association, contained in Bulletin No. 81, an extract from which is as follows:

> The maintenance of a metal bridge consists in the prevention of deterioration by rust and wear, the repairing of all damage resulting from internal or external causes, and the necessary strengthening of the structure if called upon to carry loads heavier than those for which it was designed.
>
> To attain these ends the structure must be kept free from rust by proper cleaning and painting, motion between the various parts must be reduced to a minimum, expansion joints must be kept working freely, all defects and injuries must be promptly discovered and repaired and its capacity determined as accurately as possible.
>
> The purpose of an inspection is to ascertain the condition and safety of the structure and to determine the amount and rate of deterioration and the necessity for repair or renewal. Ordinarily a thorough annual inspection made by a competent inspector will suffice for most cases where the bridge is properly constructed and is not overloaded. On the other hand, nothing short of a daily inspection will be sufficient to discover with sufficient promptness the damage caused by an accidental blow.
>
> Between these two extremes there are many reasons for making inspections of more or less thoroughness and frequency.
>
> The following scheme for inspection seems to be an average of the practice of the various roads replying to the circular. It is applicable to either the divisional or departmental system of maintenance.
>
> (1) By track men daily in connection with the inspection of the track, to note especially whether the structure has suffered any damage from drift, high water, [illegible] from fire and [illegible] settlement of the substructure.
>
> (2) Monthly by a foreman of bridge gang reporting through the foreman to the superintendent of bridges and buildings, to report their condition and safety to structures and repairs necessary.
>
> (3) Annually by an inspector, to make a detailed report of the condition of the structure for office record and to determine the amount of deterioration, safety and necessity for repairs or renewals.
>
> (4) Annually by the superintendent having charge of the structure to determine the necessity for extensive repairs or reinforcement or renewals.
>
> In addition to the foregoing, special examination should be made as frequently as required as follows:
>
> (a) Of structures that are strained too high or show signs of distress under traffic.
>
> (b) Of substructures showing signs of movement until it has been ascertained that a state of stable equilibrium has been reached, or until movement becomes so great that rebuilding is necessary.
>
> (c) After heavy floods for evidence of damage to superstructure by drift and to substructure by scour.
>
> (d) By engineering department whenever a structure is reported as requiring repairs or renewals.

The items which are to be noted by the inspector, as required by the Oregon Short Line Railroad, are as follows:

1. Class of structure.
2. Length.
3. Opening of spans.
4. Height of base of rail.
5. Approaches.
6. Ties.
7. Rails.
8. Spike.
9. Guard rails.
10. Stringers, attachments.
11. Corbels.
12. Caps, sills, timber walls.
13. Posts or piles.
14. Sway braces.
15. Waterway.
16. Culvert pipe.
17. Box culverts.
18. Paving.
19. Bench and end walls.
20. Ring or covering stone.
21. Piers and abutments.
22. Pedestal blocks.
23. Bed plates.
24. Anchor bolts.
25. Line camber.
26. Tension members.
27. Compression members.
28. Floor beams, attachments.
29. Lateral connections.
30. Hangers.
31. Long suspenders.
32. Loose pins or nuts.
33. Loose rivets.
34. Drain holes.
35. Vibration.
36. Deflection.
37. Painting.
38. Wall plates.
39. Bolsters.
40. Angle blocks.
41. Bottom chord joints.
42. Chord bolts.
43. Clamps and packing.
44. Gib plates.
45. Covering.
46. Water barrels.
47. Ladders.

This list is somewhat more detailed than are those of many other roads, but the number of items mentioned only shows the more clearly the necessity for constant and rigid inspection of such structures and the many points from which trouble may arise.

For comparison with the foregoing, herewith is submitted a somewhat similar list of items concerning concrete or stone arch bridges:

1. Class of structures.
2. Length.
3. Opening or spans.
4. Height to base of rail.
5. Approaches.
6. Ties.
7. Rails.
8. Spikes.
9. Guard rails.
10. Waterway.
11. Paving.
12. Soffits.
13. Spandrels.
14. Abutments.
15. Wing walls.

16. Piers.
17. Parapets.
18. Drain holes.
19. Expansion joints.
20. Vibration and deflection.

The points to be noted are almost entirely cracks; their location, width, length, depth and water bearing qualities. Their location will determine to a certain extent whether they are due to settlement or spreading of abutments, to setting shrinkage, changes of temperature, or overloading. Their change of size with variation in load, humidity, temperature, etc., will afford further information, especially as to their cause and cure. The amount of water coming through them and its quality is of importance in determining the dangerousness of their existence from another point of view.

In properly reinforced concrete, failure is sure to be very gradual so that there is less chance for accident than in some other types of structure, nevertheless, it is wise to inspect them just as frequently as is done on other varieties of bridges. Their foundations should be given especial care in original design, in construction, and in periodical inspection after completion, because there is almost invariably a smaller waterway left in the design of arch bridges, than in the case of the vertical abutments for a steel bridge. Worse scouring, especially in time of flood, may thus be produced and inspectors should note all phenomena along this line. On the whole, therefore, no saving can be made in the costs of inspection by the erection of concrete structures in place of steel, and hence this small but important item can be ignored in making a comparison.

One of the best known reinforced concrete construction companies gives the following reasons for the choice of concrete structures in place of steel:

STEEL BRIDGE.

Labor ....
Steel .... } All come from out of town.
Material .....

When built the bridge is.....
- Unsightly.
- Costly to maintain in roadway and paint.
- Constantly in need of inspection.
- Short lived.
- With wooden floor in danger of burning.
- Subject to rust in hidden parts.
- Noisy under traffic.

In general use only because up to the introduction of the reinforced concrete arch it was the only fairly durable low priced bridge.

REINFORCED CONCRETE BRIDGE.

Most of the carpenter and other labor is hired in the town.

Gravel ....
Sand .....
Stone ..... } Money for all these goes into the business of the town.
Cement ...
Lumber ...
Teaming .
Board ....

When the bridge is built........
- It increases in strength as it grows older.
- It is the most graceful bridge made.
- There is no maintenance expense.
- It is quiet under traffic.

When maintenance of a steel bridge is considered, a reinforced concrete bridge shows economy of investment.

It is the last claim in which the present interest centers and by the foregoing presentation, the only points now left open for comparison are costs of roadway renewal and of repainting. The former is a most difficult matter for determination since a concrete structure will always carry the regular railroad ballast and track, or the highway or street surfacing, which has to be maintained only to the same extent as the adjoining thoroughfare. It has already been stated that concrete cannot usually compete with steel highway bridges (as to first cost), when the latter are to be designed with plank flooring. The life of this material is extremely variable, depending almost entirely on the density of traffic. On Brooklyn Bridge the 2½ inch spruce plank of the wearing surface must be replaced about every four months, while the writer has known of country highway bridges in which the flooring rotted away so as to need renewal before the traffic had produced enough wear to necessitate relaying. Between these two extremes the conditions are so wide as to make this item too indefinite to be entertained except in cases or locations where the wear and cost of renewal are known. In such an instance it is only necessary to estimate the yearly expense for renewal and compute from it the percentage of the total cost of the structure. As an example, assume a bridge 100 ft. long and 30 ft. wide of which the planking has to be renewed once a year. Assume a 3 in. yellow pine wearing surface which costs, including tearing up, spikes, labor, material and supervision, $40 a thousand. This item then aggregates, $30 \times 100 \times 3 \div 1000 \times 40 = \$360$. If the initial total cost of the structure were $10,000, the yearly percentage cost of roadway renewal would be slightly less than four. This figure is known to be very modest and when it (which represents a yearly cost of 12 cents per square foot in this instance) is compared with $1.35 per square foot, which is about the yearly cost of renewal of the planking of the Brooklyn Bridge, this point is made all the clearer.

The floors of railroad bridges (unless constructed with buckle plates or similar material, on which the regular ballast road bed is carried), are largely of timber which has a relatively short life. In general it may be estimated that the wooden portion of such a floor will last about ten years in the northern part of the United States, decreasing to about six in the southern states. The cost of a floor is almost purely a function of the length of the bridge alone, so that it is impossible to assign to it a percentage value. A rough estimating figure of $3 per ft. per track is sometimes given for the timber work. The following table gives some estimated costs of steel work and railroad bridge floors for different spans, for the sake of comparison:

Span.	Type.	Cost per foot of span. Steel.	Floor system.	Total.	Per cent cost of renewal of timber work per year
45	Pl. girder	$25.00	$ 3.00	$28.00	1.1
60	Pl. girder	30.00	3.00	33.00	0.9
85	Pl. girder	39.00	3.00	42.00	0.7
100	Pony lattice	38.00	6.00	44.00	0.7
130	Lattice	29.00	10.00	39.00	0.8
125	Lattice	35.00	10.00	45.00	0.7
150	Pin	36.00	12.00	48.00	0.6
175	Pin	41.00	12.00	53.00	0.6
200	Pin	46.00	12.00	58.00	0.5
250	Pin	60.00	12.00	72.00	0.4

The painting of a steel structure is a great question. There are several hundred "best paints" on the market, some of which are good, and some of which will hardly last until the paint salesman can collect his bill. The best paints obtainable will last about six years, after which period a new painting is necessary for good maintenance. The claims of some manufacturers greatly exceed this period.

The Bridge Department of New York makes a practice of painting Brooklyn Bridge about once in three years with one good coat at a cost of about $20,000. This, of course, affords an opportunity for a thorough inspection, and, furthermore, this structure should be made to last indefinitely if careful maintenance can do so. The largest contemplated concrete arch (that of the Hendrik Hudson Bridge) has a span of only about 725 feet, while the Brooklyn Bridge center span is 1,595 ft., 6 ins., so that using it for comparative purposes is obviously somewhat straining a point. Nevertheless, its cost information is of great interest. In arriving at an annual percentage cost for painting, there is again a certain amount of uncertainty. However, a rough approximation may be arrived at from the usual estimates for steel structures. The total cost of a steel bridge varies widely from year to year, prices for similar work at different times within the writer's experience running from $70 to $105 per ton. Of this amount, about $2.50 should cover the cost of painting an average railroad bridge, while highway bridges run somewhat higher, due to their relatively lighter structural members.

It is to be noted that the first application costs relatively more for material and less for labor than subsequent ones are likely to do. On the whole, therefore, it may be assumed that 2.5 per cent is a fair original cost for painting, and if the same amount is expended once in five years, one-half of one per cent only is the annual cost of this item of maintenance.

One manufacturer of a special coating gives a table said to have been compiled from actual experience, in which the following costs are given for his special material:

Kind of Bridge.	Span.	Cost of paint per two-coat application per 100 lbs. of steel.
Highway	20	$0.08
Highway	40-60	.06
Highway	80-300	.03
Railway	80-300	.02

It is claimed for this special material

that a new application need be applied only once in ten years. This makes the percentage cost of paint per annum on the basis of $85 per ton of steel as follows:

Kind of bridge	Span	Per cent per annum
Highway	20	1.88
Highway	40-60	1.11
Highway	80-300	0.70
Railway	80-300	0.47

Collecting together now the several points discussed, a recapitulation will be as follows:

Yearly costs of inspection should be about equal, for the two classes of structures.

Depreciation and consequent sinking fund requirement for steel at least 5 per cent, for concrete not to exceed 2 per cent.

Cost of maintenance of timber if used:

For steel highway structure about 1 per cent.

For steel railway structure about 1 per cent.

Cost of maintenance of regular pavement or earth road:

Surface for concrete structure less than 1 per cent.

Of regular ballasted railway track less than 1 per cent.

Cost of painting:

Steel railway structure less than 1 per cent.

Steel highway structure less than 2 per cent.

Total maintenance costs aside from interest on first cost for steel structure from 7 to 11 per cent, depending on character of bridge and kind of flooring.

For concrete structure not to exceed 3 per cent.

Excess of steel over concrete from 1 to 8 per cent.

This is a rough average percentage figure, therefore, which a company or community should allow in the first cost figure of a concrete bridge structure over the total cost of a steel structure for foundations and superstructure combined, in a true competition between the two classes of bridges. Of course the interest charge is to be added in each case. In other words, 3 per cent of the cost of the concrete structure should be compared with 7 to 11 per cent of the cost of a competing steel structure, and that type should be selected which will give the lower result.

Or, as a special example, if the lowest responsible bid for a concrete arch is $12,000, the yearly cost to the community will probably be 4 per cent (assumed interest charge) plus 3 per cent for depreciation and maintenance. Since the yearly costs for a steel structure will amount to from 11 to 15 per cent total (4 per cent assumed as above for interest) for the steel superstructure and slightly less for the abutments, then unless the steel bridge complete can be erected for from $6,000 to $8,000, its maintenance and interest charges will be greater than those of a concrete structure.

Earth and Rock Section

Note: This Section is devoted to methods and costs of excavating earth and rock and building embankments. It will cover the grading of roads and railroads, diking and canal work, dredging, building reservoirs and earth dams, sewer and water pipe trenching, quarrying, etc.

Comments on Dump Wagons.

(Continued from p. 189, Mar. 10.)

We continue our comments and description of drop bottom dump wagons.

The Royal Dump Wagon is made by the Smith & Sons Manufacturing Co., of Kansas City, Mo. The distinguishing feature of the Royal is the patented pivot gear in the place of the fifth wheel. This pivot gear allows perfect freedom of movement in going over rocks or rough ground, or dropping into holes, doing away with any strain on the bed of the wagon. The tongue is a drop tongue held up to the front of the wagon body by a chain and double spring. The pole arranged for two horses can be changed easily for a three way hitch by adding a patented three-horse equalizer and a short tongue, the regular tongue being moved to one side of the center of the wagon.

The chains used in dumping and winding up the doors run along the side of the bed and through the box. The doors are made of wood. On the back of the wagon there is an eye bolt fastened through the piece of timber, that reinforces the rear axle, that is useful in trailing wagons when moving camp, or can be used in pulling the wagon backwards when necessary. The Royal has a patented brake that is said to be very efficient. The brake rods have turnbuckles that can be screwed up, keeping the shoes against the wheels. The height of the top of the box above the ground is 4 ft. 5 in. The wagons are made of 1½ and 2 cu. yd. capacity. The smaller wagon weighs 1,120 lbs. and the other one 1,800 lbs. For a three way hitch 50 lbs. is added to these weights. The wagons are warranted to carry a load of about 6,000 lbs.

The Michigan Dump Wagon is made by the Michigan Wagon & Manufacturing Co., of St. Johns, Michigan. The distinguishing feature of the Michigan wagon is the forged steel hinges and the loops that are attached to the box. The forgings make a strong hinge and give free play to the doors when they are open. The doors are made of flanged steel, each end and the outer edges are flanged 1 in. deep, these edges coming up against the angle iron on the under side of the box making the bottom sand tight in connection with the doors overlapping. The chains holding the doors run under the wagon and when the doors are closed the chains are at right angles to them, which assures holding them in position. The load is dumped by a lever worked by the driver's foot while the hand lever for closing the doors is worked by pulling the lever upwards, which is said to be easier for the driver than one working downwards.

The wheel base on the Michigan is [illegible] ft. 9 ins. The axles are said to be from 6 to 14 in. shorter than most other wagons. The axles are made of steel. The fifth wheel is a large circle, but it has tilt enough to allow one wheel to drop into a rut and adjust itself without springing the box, or upsetting the wagon. The body is well ironed to the running gear and these irons in front run into and form part of the neck. The neck has two angle irons bolted back to back in addition to the birch sides.

The Michigan wagons are built in various sizes, running from 1½ to 5 cu. yds. capacity. The tongue used is a stiff one.

The Oil City dump wagon is manufactured by the Kramer Wagon Co., of Oil City, Pa. This company have been manufacturing wagons for all purposes for about 50 years, and have been building a dump wagon for several years, but they have only recently perfected their present type and style of dump wagon that they believe to be one of the best on the market.

The wagon is simple in construction, yet efficient in its work. There are no chains on the sides, the chains operating the doors going under the wagon. The doors are of wood, heavily bound with iron. The hinges are long strap ones. The neck has angle irons running under the bottom and is reinforced with plates. The winding device is close against the dump box and is worked by a lever.

A stiff pole tongue is used. The wagons are made in several sizes. The trade mark of the Kramer Co. is a wagon wheel with the words "Kramer for Kwality" on it.

The Streich dump wagon is built by the A. Streich & Bro. Co., of Oshkosh, Wis. The distinguishing feature of the wagon is the patent draft attachment which draws directly from the axle. The eveners are suspended by hangers and work automatically so both horses must pull their share of the load at all times, even though one horse lags behind. This attachment does away entirely with the whipping of the pole when going over rough roads and reduces the draft of the wagon, so it is stated, 30 per cent. When one wheel gets into a rut the evener shifts over automatically and both horses pull from this point until the obstruction is overcome.

The chain operating the doors runs under the wagon the entire length of the box. The pull on the chain is positive. The wagon is dumped by a foot lever and the doors are raised by a hand lever. The doors have an equalizing device on them.

that raises one door in advance of the other, until the final pull comes, when both chains are perfectly rigid and both have an equal carrying strain. The bottoms are said to be sand tight. For street work or grading, the wagon is said to be so constructed that the doors may be but partly opened, so that the contents of the load can be spread or scattered. At the fifth wheel there is a patent rocker plate which admits of one wheel being raised over a foot or dropping into a hole the same distance without binding the plates. The dump boxes are built of Wisconsin white oak. The wagons are built in 6 different sizes, they being 1½, 2, 2½, 3, 3½ and 4 cu. yds. capacity. The 2 cu. yd. capacity wagon weighs 2,000 lbs.

The "Little Red Wagon" is manufactured by T. F. Stroud & Co., of Omaha, Neb. As its name denotes, its bright red color is its distinguishing feature. The chains working the doors run through the dump box. One lever loosens the chains and another winds them up. The doors are made of wood. The hinges being straps working on a rod. The neck of the wagon is bound on the lower edge with a heavy piece of iron. The wagon has a large circle for the fifth wheel.

This wagon is especially designed and built for use under an elevating grader for earth work. A larger wagon is manufactured for hauling stone and asphalt and for other heavy work.

The Crossland dump wagon is built by the S. Crossland Carriage & Wagon Co., of New Haven, Pa. The distinguishing feature of this wagon is that the body is all steel. Indeed but little wood is used throughout, in building the wagon. This steel body is said to weigh less than a light wooden wagon and is stronger than one much heavier. The box being sheet steel is said to be practically indestructible. The doors are made to either run across the wagon or long ways. They are wound up by means of chains on the sides of the wagon, and without levers or ratchets.

The tongue sets high, there being a bolster on the front axle. The wheel base is very short, being only 7 ft. 6 ins. The wagon is of 1½ cu. yd. capacity and weighs 1,800 lbs. Three of these wagons were used in wagon road construction during the past season, lasting 6 months, and with the expenditure of less than $5.00 per wagon, they were put in perfect shape for the coming season.

The Van Wagenen dump wagon is manufactured by the Eagle Wagon Works, of Auburn, N. Y. The distinguishing feature of this is the single chain that operates the doors. The chain goes under the body and through a pulley on the rear. The winding arbor is close up to the wagon body in front, but the neck of the wagon is not weakened by having a hole cut through as the arbor is supported by irons on the sides of the neck. The load is tipped by a foot brake and the doors are wound up by a lever.

The wagon body is put together by the side boards of the box being grooved and the end boards are fitted into these grooves, and irons running through grooves in the end boards act as further reinforcement. The neck is lined on the inside with steel plates, while heavy supporting iron is on the outside. The wagon is built in two sizes, 1½ and 2 cu. yd. capacity. These wagons weigh about 1,600 lbs. The 1½ cu. yd. wagon is 4 ft. 10 in. high from the ground to the top of the box, while the 2 cu. yd. wagon is 5 ft. 2 in. The axles are steel. The tongue is furnished as either a drop or stiff pole.

The Eagle Co. also make a dump wagon with an all-steel body. The steel body is 20 in. high and has a 6 in. wood top box. The dumping device is the same as on the wooden wagon. These steel bodies are strengthened with angle irons wherever needed. These steel wagons are made in 7 sizes, varying from 1½ cu. yds. to 3 cu. yds. Steel wagons will no doubt be used more and more as they become better known.

The Tiffin dump wagon is manufactured by the Tiffin Wagon Co., of Tiffin, Ohio. The distinguishing feature of the Tiffin is the two-gear wheels on each side and the long rods that connects them. The levers for working the device are on the outside of the wagon. One dumps the load and the other winds up the doors; an arbor at each end holds the chains, around which they wind. The chains do not pass under the doors. The doors are made either of wood or steel, as the purchaser may desire. Both kinds of doors overlap to prevent leaking. The doors each have four hinges.

The body of the wagon is built of clear white oak. The neck is covered with a solid sheet of steel, well bolted in place. The axles are made of steel. These wagons are built in four sizes, namely 1½, 2, 2½ and 3 cu. yd. capacity. The smallest wagon weighs 1,900 lbs.; will carry a load of 5,000 lbs.; has a wheel base of 9 ft. 3 ins., and the top of the box is 4 ft. 10 in. above the ground. The 2 cu. yd. wagon weighs 2,100 lbs.; has a carrying capacity of 8,000 lbs.; a wheel base of 9 ft. 3 ins., and a height of 5 ft. 4 ins.

The Climax Automatic distributing wagon is manufactured by the Climax Road Machine Co., of Marathon, N. Y. This wagon meant for distributing crushed stone is a bottom dump wagon, the doors opening across the wagon instead of longways. A winding gear controls the doors, by means of which the doors can be opened to any width, thus evenly distributing the material to any desired thickness. The wagon will also discharge the load in one place. The rear wheels overlap the front, thus acting as a roller, and making it possible to use the wagon on an unfinished road without damaging the road. The front wheels are pivoted forward so that the wheels may run over an obstruction twelve inches high without turning the box out of level. The pole is supported by a spring, taking all weight off the horses' necks.

The Acme dumping wagon is manufactured by the Acme Road Machinery Co., of Frankfort, N. Y. The dumping is simple and not liable to get out of order, and the endless chain used is entirely outside the box so as not to interfere with the dumping of the load. It has a bottom of two steel doors, each reinforced with a truss rod. The doors are hinged securely to the outside of the body, making a strong bottom that will not swell or shrink, but will close tightly at all times. The necks are reinforced with steel. The wagons are built to hold 1½, 2 and 2½ cu. yds. The small size weighs about 1,600 lbs.

The Haywood dump wagon is manufactured by the Haywood Wagon Co., of Baldwinsville, N. Y. Formerly this wagon had an endless chain that controlled the doors, but on their new model the chain instead of running along the side of the wagon body, now runs under the body, being attached to and under the doors. It is claimed that the chains running through a center bracket on the door, thus forms a truss, preventing the doors from sagging. The load is dumped by a foot lever and the doors are wound up by a hand lever. The advantage of a foot lever to trip the load is that just at the critical moment of placing the load, where it is wanted on the dump, the driver has both hands free to drive and guide his horses, while when a hand lever is used, one hand must be employed to dump the load.

The wagon bodies are made of oak, all joints being tongued and grooved. The irons are made of soft steel. The doors are made of steel and are flanged up at the sides, which in connection with the lap of the doors at the center, makes them sand tight. The neck of the wagon is reinforced on the outside by a heavy steel forging, while the whole inside of the neck is covered with No. 10 sheet steel firmly riveted and bolted through.

The axles are steel, all bedded in wood. The front coupling is built to be driven over rough roads or ground. Haywood wagons are built in sizes from 1 to 7 cu. yds. capacity. Their weights vary from 1,600 to 2,200 lbs.

In addition to the wooden wagons, the Haywood Co. made a bottom dump wagon with small steel body. Its design is the same as the wooden wagon and it has a similar dumping device. This company also has a stone spreading wagon. This too, is a bottom dump. The body of the wagon is built in the shape of a hopper, and a single gate or door closes it. The wagon spreads any dry material uniformly when the team moves at a uniform rate of speed. The door having a flange on the side prevents any of the material running out at the sides, thus getting under the wheels. It can also be used for a regular dump wagon. It is made in 4 sizes, 1, 1½, 2 and 2½ cu. yds. [illegible]. The weights run from 1,100 to 1,700 lbs.

The Columbian dump wagon is manufactured by the Columbus Wagon Co., of Columbus, O. The distinguishing feature of this wagon is the high braces on the sides of the wagons, which give free play to the doors. The chains regulating the doors run under the dump box and wind around an arbor in front of the wagon. One lever both dumps and winds up the doors, but this lever has a foot rest on it that can be used to dump the load. The winding drum or arbor is placed in front of the neck, which prevents the hole cut through the side from weakening the neck. The tongue of the wagon sits high as there is an arched bolster over the axles. A large circle is used as a fifth wheel. The wagon is well ironed throughout.

The Symons dump wagon is manufactured by the J. L. Smith Co., Old Colony Bldg., Chicago. The distinguishing feature of this wagon is the doors and the hinge on the rear door. The doors instead of opening longitudinally with the bed, open across the wagon. The rear door is divided into two sections and has a large goose necked shaped hinge. When the door is open to dump the load the back part swings well behind the wagon. The chains, to pull the doors back into a closed position, are on the sides of the wagon and as they are wound up the pull is almost a direct one, and that together with the forward movement of the wagon scrapes off the top of the dumped load, thus partially spreading the material as it is dumped. This together with the proper spacing of the loads would make a rough spread of the material. The method of swinging the doors prevent them from stalling the team. The depth of the wagon body allows of the wagon being short coupled.

The load is dumped by means of a foot trip and the doors are wound up by means of a lever. The neck of the wagon is strengthened by a heavy iron. The wagon has a large circle for a fifth wheel.

The Government of the Philippine Islands has organized a "Bureau of Public Works" and in this bureau a Division of Irrigation. An annual appropriation of 750,000 pesos is provided for the surveys, plans and construction of irrigation works, and surveys are now in progress. The Governor of the Islands has applied for the services of a consulting engineer from the Reclamation Service, and an effort will be made to detail a competent engineer from that Service at the proper time, at the expense of the Philippine Islands.

The production of pig iron in Germany (including the Grand Duchy of Luxembourg) last year aggregated 11,813,511 tons (at 2,204 English pounds), against 13,045,760 tons produced in 1907.

Method of Operating a Churn Drill for Prospecting.

In a recent issue of The Mining World Mr. Doss Brittain in an article on prospect drilling in the Joplin district, describes in detail the method of operating the drills in that class of work. For putting down blast holes the same methods are used so we give the following extracts from that article.

These drills are moved from place to place by their own traction, the excellent macadam roads of the district making the removal a matter of but little difficulty. Under very favorable circumstances a drill of good traction can easily make four to five miles per hour.

After the location of the hole is determined the machine is leveled up with jack-screws and blocks. Longitudinally the drill should be level as, if the drive wheels are too high, severe strains may be set up in the frame; if too low, the drill bit will hang too close to the frame, the drive clamps will strike the derrick and other inconvenience be caused. Laterally, great care should be used to have the drill level, as a slight departure may cause trouble with the sand line friction, causing it to catch unexpectedly, or to fail in operation. On account of derangement of the derrick and frame it is sometimes necessary to incline the drill from the perpendicular, for it to work properly. Laterally the drill may be leveled on the spirit level placed on a wooden cross piece, between the boiler and engine, or on a shaft. Longitudinally it is leveled by using the drill cable as a plumb line.

Leveling is accomplished by blocking the upper of the drive wheels securely, and raising the lower in the same manner as if stuck in the mud, two blocks being used to scotch it thoroughly. All blocking and cabling should be given enough rigidity to resist vibration when the drill is in operation. The derrick end is put in position by the use of 16 in. jack screws, footed over boards, 2x10x11 ins. on each of which rest the ends of another 2x10 in. x 5 ft. Between the corners of the frame and jack-heads, boards are placed. The jacks are then screwed up until the drill is level, and they take all the weight. On some drills devices are provided for locking the frame to the axle, so as to take the strain off the king bolt. Blocks are sometimes used between the bolster and axle for the same purpose. Two men are employed in the operation of a prospect drill including the drill man and his helper.

The spud consists of a cylindrical tool fitting over the rope and around the bit. It is used by being let drop heavily upon any boulders that may wedge the bit in the hole. The rocks are crushed and the bit loosened. The jar bumper is let down heavily to loosen the jaws if they become fastened. The rope spear consists of a sharp instrument let down with force upon the rope if it breaks and drops into the hole. It is screwed to the stem and the impact causes the barbs to pierce the rope, thus making it possible to raise the string of tools. The slip socket consists of a hollow tool fitted with teeth and capable of dropping over the end of the battered stem, frequently dislodging it.

The drill bit should not be allowed to become dull, but kept sharp and in good condition. The cutting edge of the bit is a straight line at right angles to the middle line of the bit. Considerable experience is required to sharpen and temper drill bits properly. The process requires about one hour.

The sand pump is generally free from trouble, but a number of foot valves on hand will often be found of service. Wear occurs at the bail and where the valve comes in contact with the valve seat. If leakage at the valve occurs from wear or obstructions between the valve and valve seat, the old valve should be replaced with a new. Leakage in old pumps sometimes occurs at the rivets. By watching the pump as it ascends, leakage can be determined. If it is not full, it should be lowered with a rush, and if the leakage continues, the obstruction, if this is the cause of the leakage, should be knocked out after the pump has been emptied.

If the sand pump becomes fastened by a pebble dropping in and a hard jerk with the sand line does not loosen it, the sand line may be attached to the drilling cable, and the pump removed with the cable drum. The force should be exerted gradually, as a sudden jerk may break the sand line, or the handle of the pump. Should this occur the pump must be recovered by fishing or drilled to pieces in the bottom of the hole. Rather than resort to the latter alternative it is sometimes preferable to start a new hole if the first has not progressed very far.

In pumping red clay or other sticky material, considerable vacuum must sometimes be overcome. Skin friction results from fine homogeneous material rising between the sides of the pump and the rock walls or casing. This can usually be overcome with a vigorous pull amounting sometimes to as much as 1,000 lbs.

In order to prevent as far as possible the loss of tools and inaccuracies in the results of the drilling, the hole is "cased." But for this precaution pebbles and boulders from soft layers fall into the hole and wedge the bits so it is difficult or impossible to dislodge it. The casing of the hole also forms a safeguard against pieces of ore falling in from the top of the ground or from the sides of a pocket of an upper stratum of ore, through which the drill has already passed, and which has been pulverized by the bit. In drilling blast holes casing is seldom used and when it is it is drawn out before the blast is made. The cuttings brought up in the sand pump when casing is not used, might show ore at certain depths when in reality there might be none at those depths.

A small piece of ore falling in from above is sufficient to "salt" the hole for several feet. An accident of this kind might indicate a very rich deposit of ore, 15 or 20 ft. thick, and cause the expenditure of $4,000 to $7,000 sinking a shaft, when in reality the ground may be barren. Too great care cannot be exercised to keep the drill hole free.

While the hole is being drilled a piece of steel casing or heavy tube that has the same inside diameter as the hole cut by the drill is driven to the bottom of the hole, and the drill again set to work. After a time another joint is screwed to the first, and the whole driven to the bottom. The process is continued until solid rock is struck, when the diameter of the hole is reduced.

Should an unsuspected stratum of soft ground be encountered below a layer of hard rock, the casing is drawn and the hole "reamed," enlarged, with the big bit and the large casing driven down to solid ground. The casing is drawn by "frictioning in the bit," which is done by throwing cinders about it until it is thoroughly fastened in the casing. When the bit is drawn it brings the casing with it. If the casing cannot be drawn by ordinary methods a charge of dynamite is sometimes used to blow it loose.

After the large casing has been driven down to hard ground, the hole is continued with smaller bits until it is of the required depth. When the hole is completed, it is marked by leaving a piece of casing extending a foot or two above the ground or by a stake. More commonly it is marked by the pile of cinders from the engine, and the cuttings of the drill. The hole is then numbered and its record kept for future reference.

Two opinions of importance to the New York State barge canal work have been rendered by State Attorney General O'Malley. In one he holds that the state can legally enter into a contract on the barge canal to divide the work contracted for into sections of one mile each and to authorize the contractor on the completion of each separate mile to turn it over to the state and be released from the necessity of maintaining it. This opinion affects the awarding of contract No. 20, providing for the dredging of the Mohawk River, for which bids were asked four times without securing a contractor who would agree to do the work within the state engineers' estimate, which was about $4,000,000, owing, it is claimed, to the uncertainty attached to the cost of maintaining the work after its completion. The other opinion holds that the state may abandon and dispose of such land as has been appropriated for the barge canal and which is not actually needed.

The headings of the last of the McAdoo tunnels under the Hudson River between Manhattan and New Jersey were connected on March 11.

The Method of Pumping and the Cost of Sinking a Wet Shaft at Tombstone.*

By Elton W. Walker.

In sinking the main pumping shaft of the Tombstone Consolidated Mines Co., there was struck what is probably one of the largest continual flows of water ever dealt with in the history of shaft-sinking. Pumping from this shaft was started in January, 1902, and has been practically continuous ever since. From the beginning 2,550 gal. per min. has been pumped. During the past year the average pumped has been approximately 3,400 gal. per min. Water was first entered at a depth of 570 ft. below the collar of the shaft, and the mines of the company have now been drained to a depth of 837 ft., so that development is now in progress at a depth of 1,000 feet.

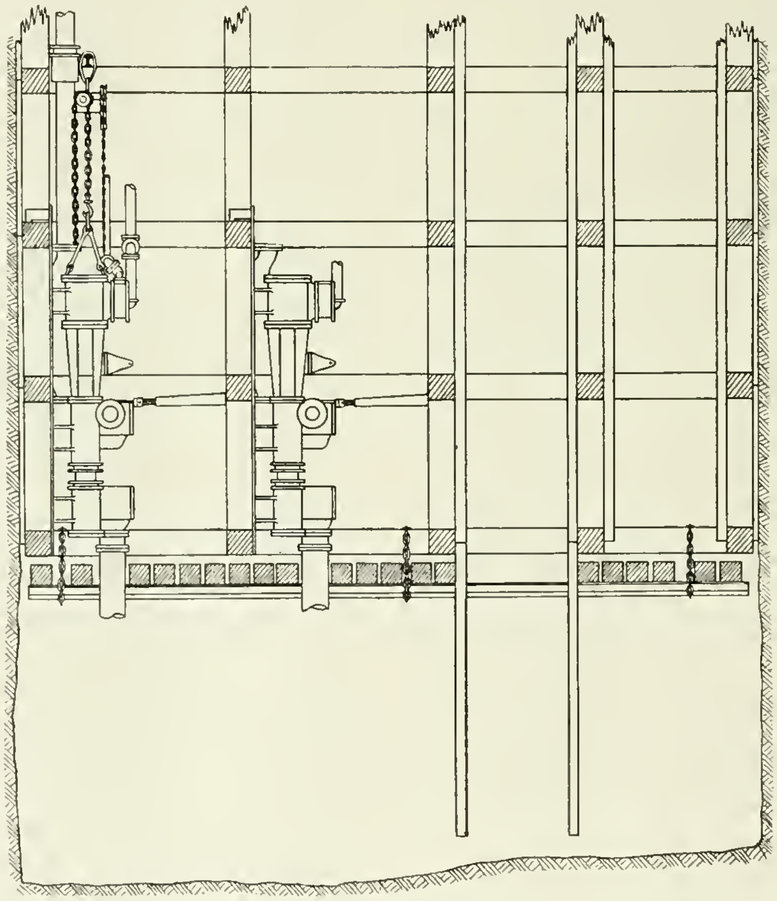

Fig. 1—Showing Timbering, Arrangement of Pumps, etc., at Shaft Bottom.

While the amount given above represents the total water pumped from the shaft, a portion of it entered at the levels, but it is safe to say that the shaft has been sunk against a continuous flow of from 2,200 to 2,400 gal. per min. At times this amount has been exceeded, rendering it necessary to provide one or two extra sinking-pumps in addition to the regular equipment, which consists of four.

The shaft measures 8 ft. 10 in.x23 ft. 8 in. outside of timbers—10x10 in. Oregon pine—and consists of four compartments. Two compartments, 5 ft. 9 in.x7 ft. were used for the sinking-pumps, piping, etc., and the remaining two compartments, 4x7 ft., were used for hoisting purposes. In the end pump-compartment a small cage 24 in. wide was used for the convenience of the pump-men in handling the sinking-pumps, pipes, etc. This narrow width of cage was necessary in order that it might pass between the discharge-pipes of the sinking-pumps and be lowered close to them. The remaining pump-compartment, in addition to carrying two such pumps at the bottom of the shaft, contained the main discharge-columns from the station-pumps as well as the steam and air-pipes. The inner hoisting-compartment was used in sinking the shaft and the remaining compartment for hoisting from the working levels above. Sinking was done with a cage and car, running on removable guides extending below the timbers. In Fig. 1 is shown the elevation of the bottom of the shaft, together with sinking-pumps, bulkheads and accessories.

The pumps used while sinking were of the duplex type, 14x8x12 in., having 8-in. suction and 6-in. discharge, and were made by the Fred M. Prescott Steam Pump Co. These pumps have a rated capacity of 600 gal. per minute under a 250-ft. head, and gave excellent satisfaction at all times, suffering little or no damage from blasting; in fact, a couple of these pumps remained in continual operation at the bottom of the shaft for several years without being brought to the surface for overhauling. As there was always the possibility of their being drowned—as occurred in a couple of instances—all nuts that might become loose, and so put the pumps out of commission, were provided with cotter pins in order that the pumps might be kept in operation even if submerged. In one instance, after the pumps had been drowned and were covered with 90 ft. of water, when steam was admitted they started up after a short interval of warming.

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*Reprinted from the "Mining and Scientific Press."

The pumps were handled with 5-ton duplex chain-blocks, hung on steel rails, which rested on the timber sets above the pumps. When the pumps are in position the chain blocks are tightened and support most of the weight of the pumps. The pumps are held to the side of the compartment by small jack-screws placed between the water chest and the opposite side of the compartment. The jacks were fastened to the pumps by a piece of rope so that there would be no danger of dropping the jack into the sump if it should become loosened.

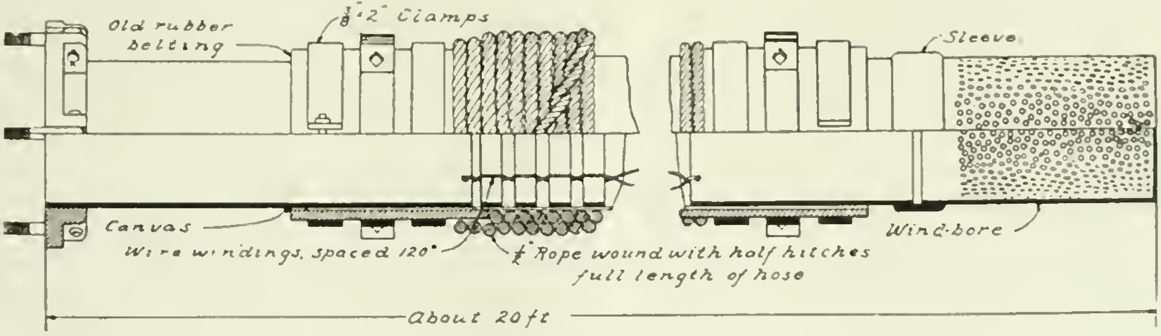
Old rubber belting
1/8"·2" Clamps
Sleeve
Canvas
Wire windings, spaced 120°
½" Rope wound with half hitches full length of hose
Wind-bore
About 20 ft

Fig. 2—Details of Home-Made Suction Pipe.

Thus there was little or no vibration in the pumps, and they could be easily freed for lowering. To the back of each pump is bolted two hangers of 3½x1¼ in. iron, having at the upper end an arm, which is hung on the timbers of the shaft. These hangers support part of the weight of the pump, but are used more for a temporary support while moving the chain-blocks.

Each pump is provided with separate steam exhaust and discharge-pipes extending to the pump-station above. In order to facilitate lowering of pumps and connection of pipes, each pipe is provided with a long slip joint. These slip-joints are always left connected to the pump, and provide for any variations in the length of the sections of pipe used when lowering the pumps. The steam-pipe is provided with a valve at each pump as well as one at the station above. In this way if the pump becomes submerged it is possible to regulate it from above if the lower valve is left open.

The shaft sets are 5 ft. from center to center and the pumps are lowered one set at a time. The method used in lowering is as follows: The pipe-connections are first loosened to allow the pump to swing free of the timbers, when it is lowered 5 ft. with the chain-blocks and hung on the timbers. The expansion-joints, which have a movement of 5 ft., are then pulled out and the pipes connected. At the second lowering the pumps are dropped the same distance, and the expansion-joints are closed together, allowing a 10-ft. section of pipe to be put in place. The third lowering is done with the expansion-joints as at first. At the fourth lowering the 10-ft. section of pipe is removed and a permanent 20-ft. length put in place. This operation is repeated as the pumps are lowered. Ordinarily three or four hours are consumed in lowering, but in an emergency it can be done in considerably less time. In fact, three pumps have been lowered in five hours.

In the earlier part of the sinking, ordinary 8-in. plain-bore rubber suction-hose wound with two layers of a cheap grade of ¾-in. manila rope, to protect the hose from flying rock when blasting, was used; but later a home-made suction hose (Fig. 2) was devised, which cost about one-third the rubber hose and proved more satisfactory. In making the hose, 8-in. pipe was cut into rings about 1¼ in. wide, and these rings were wired together, leaving a space of about ½ or ¾ in. between the rings. The whole was then covered with three layers of heavy canvas sewed on, each layer being made air and water-proof with pine tar. The hose was then covered with rope, as was done with the rubber hose. The total cost of making an 18 ft. length of hose was $25.50. This cost includes all labor and material except the rings, which were cut from scrap pieces of pipe. The rope and the winding of it are also omitted, as this cost would be the same if a rubber hose were used.

In order to protect the sinking pumps and shaft timbers when blasting, as well as to protect the men working below, a bulkhead was used below the shaft-timbers, as shown in Fig. 1. Two steel rails the length of the shaft were hung below the wall plates by chains and on these 8x8 in. timbers were placed close together, leaving an opening through which the hoisting cage could pass.

On account of the great volume of water it was not possible to remove the suction hose when blasting, only the lower end being raised from the bottom with chain blocks. The pumps were stopped when blasting so that when the holes were shot there was from three to five ft. of water covering the holes; this water acted as a cushion and helped to protect the timbers and pumps.

Detailed figures are not available as to the cost of sinking the upper part of the shaft, but the cost of sinking from 879 ft. to 1,017 ft. was as follows:

Powder	$ 468.21
Caps	25.08
Fuse	141.96
Lumber, lagging, etc.	1,772.85
Supplies, oils, grease, slickers, boots, etc.	1,557.97
Compressor and drills	660.27
Labor (miners)	8,089.95
Labor (miscellaneous)	231.80
Total	$12,719.10
Feet sunk	138
Cost per foot	$ 92.38

Owing to operating conditions, it was impossible to arrive at the cost of hoisting from the shaft with any accuracy, and for this reason the cost of hoisting is not included in the above.

The Value of Prospecting by Drilling with Some Costs.

Mining engineers are rapidly learning the value of prospecting by drilling and civil engineers can learn much from their experience. It is as important to know of the character of the soil and rock upon which a structure is to be built, as to know its value for mining purposes. Shafts give such information but as a rule at a prohibitive cost, as illustrated by the following extracted from an article by Robert Marsh, Jr., in the "School of Mines Quarterly" on "Sampling and Assaying Copper Ores of the Ely District."

Churn drills of the "Keystone" and "Star" type were extensively employed in prospecting. As these drill holes were sunk, the sands and cuttings were pumped up and caught in wash-tubs for each five feet of depth drilled in the ore zone. Each of these representative samples was dried, coned and quartered, and sent to the assayer. Few of the holes exceeded 500 ft. in depth and as a whole the ground was not difficult drilling. From this work much valuable information was acquired as to the likely location, thickness, extent and value of the ground; one company having thus developed about 15,000,000 tons of milling ore.

The result of this work was shown by platting the drill holes on the claim map, in conjunction with an ideal sectional map of all the holes correspondingly lettered. The sectional portion of the map was drawn to a much larger scale; and the elevations of the tops of the holes taken from a common datum plane; these elevations, the five-foot assays and the depth of the holes accompanying.

Although some companies in the district have done a considerable amount of prospecting at depth by means of vertical shafts —work probably done before the advantage of drilling was locally appreciated—drilling has found much favor because of satisfactory results obtained cheaply and rapidly. The cost of drilling ranges from about $1.00 per ft. in very favorable ground to $2 in ground of difficult character, with an average of about $1.50 in fair ground. The rate of advance will average from 20 to 25 ft. per day in fair ground. A few typical examples may be of interest:

Hole No. 1.—Time, 11 days; footage, 235 ft.; total cost, $306.60; cost per ft., $1.30; conditions favorable.

Hole No. 2.—Time, 16 days; depth, 412 ft.; total cost, $770.16; cost per ft., $1.86; good hole, standing well.

Hole No. 3.—Time, 14 days; depth, 230 ft.; total cost, $537.28; cost per ft., $2.33 Trouble with crevices and fitchering.

The above costs include: labor, superintendence, tool-sharpening, oil, hauling water 2 to 3 miles, wood fuel costing about $6.00 per cord, maitenance, repairs and casing where necessary. There were worked two 12-hour shifts per day, the drillers receiving $6 per shift and the helpers $4.05. Moving the drill is not included. Water and wood were expensive items.

The cost of two compartment prospect shafts in this district have ranged from $18 to $26 per ft. to depths of 50 to 170 ft. The rate of advance is about 2½ ft. per shift.

The value of such drilling work depends largely upon the care taken of the samples, the ability to save the cuttings (in fissured ground they are likely to be lost), and the judicious location of the drill holes.

The Chilean Government received two tenders on March 1 for constructing the proposed railway to connect Arica, Chile, with La Paz, Bolivia. Both of these tenders were from foreign firms, the Deutsche Bank of Berlin, Germany, submitting one and the firm of Sir John Jackson, Ltd., London, England, submitting the other.

Roads and Streets Section

Note: This Section is devoted to methods and costs of road and street construction. It will cover road building in all its details, the construction of pavements, sidewalks and gutters, the testing and use of paving materials and the machinery and tools used in road building and paving.

Economic Hints for Macadam Road Contractors.

(Continued from March 10 issue.)

[Three hints were inadvertently omitted from our issue of March 3, and are inserted here as hints 23a, 23b and 23c.]

23a. Use your watch to time wagons that are being loaded; if it takes more than 2 minutes to load a wagon, either the bottom of the bin is too nearly flat, or the men are lazy. If 10 teams arrive at 7 a. m. to load from a bin, and it takes 6 mins. to load each team, the last team will not leave with its first load until 8 o'clock.

23b. Even if you make your own bin, buy steel chutes for discharging the stone into wagons. A home made wooden chute is heavy, and hard to raise, but a light steel chute can be quickly dropped and raised.

23c. If you make your own bin and intend to move it about, bolt the timbers together and avoid using any spikes. Have a drawing and blue prints made of your bin, and don't leave it to an ordinary carpenter to throw one together according to his own crude ideas of what is wanted. A bin that can be quickly taken down and quickly erected again must be planned in advance, and not designed on the ground.

45. To ascertain whether the teams engaged in hauling the stone are doing a fair day's work or not, use a scale map showing the location of the stone supply and the location of the road. If no map showing the quarry location is available, make one. Distances can be measured with an odometer, or cyclometer, or by fastening a rag to one spoke of a carriage wheel and counting the number of revolutions between given places.

46. A team traveling over poor earth roads, going loaded and returning empty, should average 16 to 18 miles per day of 10 hours. The same team traveling over good gravel or macadam roads should average 18 to 20 miles. The writer has had good teams average 25 miles.

47. If teams are hired, pay a bonus for every ton-mile hauled in excess of a certain minimum of ton-miles. If, for example, it is found that teams are averaging 10 miles loaded with 3½ tons, returning empty, or 35 ton-miles per day over macadam roads, and if a team and driver are costing $3.50 a day, the cost of hauling is 10 cts. per ton-mile. By offering a bonus of 5 or 6 cents per ton-mile for all over 35 ton-miles daily, it will usually be found that the teamsters will load their wagons heavier and make more trips to earn the bonus.

48. In hauling large loads of coal, etc., provide portable platform scales at the stone bins, and weigh every load. This is far more accurate than measuring loads. Moreover, the horses should be weighed every fortnight to ascertain whether or not they are losing weight, due to being crowded too hard.

49. In hauling large loads of coal, etc., in cities, it is becoming the practice to use three horses on each wagon. This practice can well be adopted in hauling broken stone. Indeed, it is common practice in California and other western states to have four horses haul two wagons in tandem, or one heavily loaded wagon alone.

50. In estimating how much work a team may reasonably be expected to perform, bear in mind that the length of haul on road work changes every day. If the haul is such that 10 trips can just be hauled today, and 4 teams can just handle all the crusher output, tomorrow it will require a fifth team, and none will then be working to capacity for a few days until the haul has lengthened.

51. Careful account should be kept of the time lost due to breakdowns, etc., at the crusher. This should be done not only with the object of reducing such delays by ascertaining their frequency and cause, but in order to know whether the teams have been delayed because of lack of broken stone in the bins.

52. Never spread the coarse broken stone on the road by hand. A man working with energy can spread 30 cu. yds. of loose broken stone from the piles, if the piles are small (less than 1½ cu. yds. each), but the average contractor usually has one man spreading for every 15 cu yds. of loose broken stone delivered per day. In either case, this cost can be greatly reduced by using a small leveling machine hauled by two horses. The Baker Mfg. Co., 725 Fisher Bldg., Chicago, makes such a machine, which is called the "20th Century Grader." C. N. Carpenter Supply Co., Canton, Ohio, makes a machine called "The Little Yankee Road Leveler."

Using small machines of this type the writer has had a team, with driver and one man managing the machine, spread 50 cu. yds. of loose broken stone per hour. A regular "road machine" drawn by four horses can be used for the same purpose, but is ordinarily not so economical, not only because there is not enough stone spreading to keep it busy a small fraction of the time, but because in turning around the earth shoulders and subgrade are torn up. If one of the above described small two-horse machines is used, it can ordinarily be operated by the team used to haul the sprinkling wagon, for it takes only a small fraction of a day to spread all the stone delivered from a portable crusher.

53. When stone is thus spread with a machine, it is never spread to perfect crown. Hence some contractors who have tried the machine have abandoned it. The writer was, he believes, the first to use this type of machine for spreading broken stone, and he found that it was necessary to supplement its work by some hand work in order to secure an even surface and proper crown of the macadam. After some experimenting, he found that the best tool for this finishing is a potato hook, such as can be bought at any hardware store. One man with a potato hook follows the spreading machine and readily completes the spreading at the rate of 15 cu. yds. of loose broken stone per hour. Hence it costs 1 ct. per cu. yd. of loose broken stone to do the rough spreading with a machine (wages of 2 horses and 2 men being 50 cts. per hour), plus 1 ct. per cu. yd. to do the finishing by hand (wages being 15 cts. per hour).

54. The screenings are not to be spread over the broken stone until it has been well compacted by rolling. Then the screenings are spread with shovels from the piles along the roadside. The shovelers must spread the screenings by casting them from the shovel with a sweeping motion, so as to distribute them evenly over a large surface. One man should spread at least 10 cu. yds. of screenings per day.

55. From a large number of carefully made records the writer ascertained that a 6-inch layer of loose broken stone can be compacted under a steam roller to about 4¾ ins. in thickness. No greater compacting than this is possible where a hard stone is used, and, if a very hard stone is used, somewhat less consolidation is effected. At this rate 1.3 cu. yds. of loose broken stone can be rolled down to 1 cu. yd. There will still remain enough voids in the stone to require about 0.3 cu. yds. of screenings to bind each cubic yard of rolled macadam, and to furnish a slight surplus of screenings on the surface of the road. If it is desired to estimate the exact thickness of the layer of screenings required to bind the macadam and provide a surplus, apply the following rule: *Take one-quarter of the thickness of the rolled macadam in inches, and add one-third of an inch to provide for filling the surface voids and for surplus.*

To make a cubic yard of macadam 6 ins. thick after rolling requires 1.3 cu. yds. of ½ in. to 2½ in. stone and 0.3 cu. yds. of screenings (½ in. and less in size), making 1.6 cu. yds. of loose broken stone and screenings per cubic yard of finished macadam.

56. In a macadam road 6 ins. thick (after rolling), 16 ft. wide and 100 ft. long there are almost exactly 30 cu. yds. of rolled macadam. Hence it will require 1.3 x 30, or 39 cu. yds. of loose broken stone and 0.3 x 30, or 9 cu. yds. of screenings, per 100 ft. station. This is equivalent to 1,584 cu. yds. of rolled macadam per mile of road 6 ins. thick and 16 ft. wide, or 2,059 cu. yds. of loose broken stone and 475 cu. yds. of screenings.

57. It is better to reduce all records of materials and costs to the cubic yard of rolled macadam as the unit, instead of using the square yard as the unit, for the square yard may be 4, 6, 8, 9, 10 or 12 ins. thick. To reduce costs per cu. yd. to costs per sq. yd., divide the specified thickness of the macadam into 36, and use this quotient as the divisor for cubic yard costs. Thus, on a 6 in. macadam, 36 ÷ 6 = 6, hence if such macadam costs $3.60 per cu. yd. in place, it will cost $3.60 ÷ 6, or 60 cts. per sq. yd.

58. A very common specification is to require that the rotary screen shall have three sizes of circular openings, namely, ½ in., 1¼ ins. and 2½ ins. In crushing stone of average hardness, such as limestone, the writer has found that the following percentages will be produced:

	Per cent.
Through the ½ in. screen..........	16
Through the 1¼ in. screen..........	24
Through the 2½ in. screen..........	60
Total..........	100

In this case the crusher jaws were set close, so as to produce little stone more than 2½ ins. in diameter. It will be seen, from the data in hint No. 55, that about 20 per cent of the total stone and screenings must be screenings (since 0.3 cu. yd. is 20 per cent of 1.6 cu. yds.). Hence it is usually necessary to buy some additional screenings or else to use loamy sand, or the like, for binding at least part of the macadam.

(To be continued.)

Gunnison Tunnel of the Colorado, Uncompahgre Project by the U. S. Reclamation Service has been advanced in February 275 ft. in the east portal heading and 325 ft. in the west portal heading, leaving 2,310 ft. between the headings on March 1. At the river portal 50 ft. of tunnel has been timbered, 45 ft. of timbered tunnel has been lined with concrete, and the concreting of the headworks has been practically completed. Three hundred and forty-five feet of lining have been placed in the west heading. The flow of water into the tunnel has been practically constant throughout the month at 8.5 second feet at the west portal, and 2 second-feet at the east portal. The tunnel is now 75.2 per cent completed.

The Interborough Rapid Transit Co. of New York City has submitted to the New York Public Service Commission a comprehensive outline of its proposed extensions in Manhattan Borough and the Bronx. The cost of these improvements is estimated at $50,000,000.

Method of Constructing Oiled Sidewalks at San Leandro, Cal.

The first oiled sidewalk in San Leandro was constructed [illegible] years ago. No care was taken to secure any particular quality of crude oil and no systematic method was followed in its application. The oil was merely heated and spread upon the sidewalk after which sand or fine gravel was thrown over it to keep the oil from running down over the curb. These first sidewalks were not exactly a success. However, the experiment was continued, and special machinery constructed to spread the oil and roll the sidewalk after its application, and now the city has about four miles of excellent oiled sidewalks. The method now employed in constructing these sidewalks is described in "Pacific Municipalities" as being as follows:

The sidewalk is first macadamized by using a rock base about 4 ins. thick covered with 1 in. of fine screenings. The base and screenings are each well rolled separately. The sidewalk is graded on an incline of ½ in. to the foot, so that on a 12 ft. walk it is 6 ins. higher at the property line than at the curb. A straight edge is used and care taken to get the surface straight and absolutely flat, without any depressions.

If it is a sidewalk that has already been macadamized at some time past, it will be necessary to dig the old rock out, after which it may be rescreened and applied and rolled in the same manner as new rock.

In case any weeds are found growing on the sidewalk, a little rough salt is distributed over that part to kill them, as it is found that some kinds of weeds have no respect for oil, at least until the surface gets so hard that nothing can penetrate it.

After the walk has been wet down and rolled hard, it is allowed to dry out pretty well and the first coat of oil is then applied. The oil used must not be less than 14 degrees gravity and be heated to at least 100 degrees F. After applying, it should be allowed to stand for three or four days, when it will be found to be pretty well absorbed. About half an inch (not any more) of dry sand should then be spread evenly over the surface and a hot roller applied.

The roller should have a fire-box and be kept very hot, a thin grade of crude oil may be used as fuel for the roller. The roller itself should weigh about 400 lbs.

After a lapse of about five days a second coat should be applied, this time using an oil of 11 degrees gravity and containing not less than 60 per cent asphaltum. It should be heated to about 125 degrees F., and applied and treated in the same manner as the first coat.

After the hot roller has been applied on this second coat, common dust off the street should be thrown on and swept over the surface in order to thoroughly dry it. The work should be done in early summer, if possible.

A 12 ft. sidewalk, 50 ft. long, constructed in this manner, costs about $20, being 40 cts. per lineal foot. It is elastic and consequently easier under foot than cement; and because of its elasticity is not so seriously affected by growing trees. Oiled sidewalks improve with time, the oil turning into a hard tenacious gum, binding the whole walk into one solid mass.

Cost of Three Sections of Concrete Sidewalks.

The following data, taken from the Canadian Engineer, not only show the cost of constructing three sections of concrete sidewalks, but also offer a comparison of the relative cost of hand-mixed and machine-mixed concrete. The work was done by three gangs, two gangs laying hand-mixed concrete, and one gang laying machine-mixed concrete:

Section A was hand-mixed, and was 300 ft. long and 5 ft. wide, comprising 166.6 sq. yds., and costing as follows:

Labor—	Total.	Per sq. yard.	Per sq foot.
1 foreman, 8 hrs., 15 laborers, 120 hrs..	$ 53.20	$0.32	$0.03½
Material—			
Cement	$ 86.00	.51	.05⅔
Gravel	34.08	.20	.02¼
Total cost	$173.28	$1.03	$0.11½

Section B was hand-mixed, and was 380 ft. long and 5 ft. wide, comprising 211 sq. yds., and costing as follows:

Labor—	Total.	Per sq. yard.	Per sq. foot.
1 foreman, 8 hrs., 18 laborers, 144 hrs..	$ 59.10	$0.28	$0.03
Material—			
Cement	109.20	.51	.05⅔
Gravel	49.70	.23	.02½
Total cost	$218.00	$1.02	$0.11⅖

Section C was machine-mixed, and was 575 ft. long and 6 ft. wide, together with an approach 27 ft. by 2¾ ft.—altogether, 391.5 sq. yds., and cost as follows:

Labor—	Total.	Per sq. yard.	Per sq. foot.
1 foreman, 8 hrs., 23 laborers, 184 hrs..	$ 55.70	$0.14	$0.01½
Material—			
Cement	202.80	.51	.05⅔
Gravel	92.30	.23	.02½
Total cost	$350.80	$0.88	$0.9 9-10

The sidewalks were 6 ins. thick. No allowance has been made in the above costs for use of tools or machine.

Comparing the costs per square foot, it will be found that the material cost the same in each case, but that the cost of machine mixing was about two-thirds less than hand-mixing.

Notes on State Highway Work in 1908.

In our March 10 issue we gave an outline of the highway work done in 1908 in a number of states. Additional reports have since been received and are given below.

OHIO.

During the fiscal year ending Nov. 15, 1908, the State Highway Department let contracts for 19 roads. The aggregate estimated cost of the 19 contracts is $256,186. The amount assumed by the state in these contracts is $93,528, the remainder being assumed by the counties in which the roads are to be constructed.

The accompanying table shows the cost of several roads completed in 1908. The figures for excavation is the engineer's estimate and the cost of this portion of the work is included in the cost given in the table. The roads were built by contract. The total cost includes contract price and engineering, etc.

COST OF MACADAM ROADS COMPLETED IN OHIO IN 1908.

Road.	Length. Miles.	Width of macadam. Feet.	Depth of macadam. Inches.	Excavation. Cu. yds.	Total cost.	Cost per mile.
Ashland-Hayesville	1.55	10	9	9,356	$11,063	$7,137
Conneaut-Southern	1.34	14	9	4,365	12,968	9,642
Sugar Creek	1	12	9	6,031	7,635	7,635
Bethesda Southern	1.2	10	9	7,217	8,505	7,088
Belmont Southern	1.2	..	..	2,953	6,209	5,175
Salem-Perry	1.08	12	9	4,500	8,330	7,713
Hayden Bridge	1.6	14	9	4,366	9,250	5,781
Chicago Junction Southern.	1	12	9	3,662	7,080	7,080
Yorkville	1.22	10	9	15,450	10,270	8,418
Ravenna-Infirmary	1.75	12*	9	5,863	13,271	7,583
Wooster Northern	1.03	14†	8	2,453	7,384	7,169

*12 ft. wide for 6,410 ft.; 14 ft. for 2,820 ft. †14 ft. for 3,300 ft.; 10 ft. for 2,153 ft.

A number of roads paved with brick have been constructed under the supervision of the State Highway Department and the accompanying table shows the cost of three of such roads. Two of these roads were completed in 1907 and one in 1908:

Road.	Length. Miles.	Width Paved Feet.	Total cost.	Cost per mile.
Zanesville-Wayne Township	1	16	$11,177	$11,177
Tuscarawas River	1.346	10	11.210	8,304
Brady Cemetery	.86	14	12,777	14.857

The costs include excavation, foundation, concrete curb, etc.

WISCONSIN.

Highway work in this state has not yet reached the stage of state aid, and the work that Highway Division of the Geological and Natural History Survey is doing is simply to aid the towns and counties with engineering advice in the construction of their roads and bridges. The work done under the Division's charge has been more or less of an experimental nature in each locality, and in most cases no records of costs worthy of submission were kept. The roads built were for the most part 9 ft wide, and in contradiction to the beliefs of many highway engineers, this type of road seems to be successful. In 1908 the Division built 1.5 miles of gravel road of an average thickness of 8 ins. and a width from 9 ft. to 14 ft. About 7.3 miles of 6-in. macadam road were also built. As stated above the roads were principally 9 ft. wide.

Besides the actual stone and gravel road construction done by the Division it examined or surveyed 93 pieces of road, including all classes of construction.

Another important part of the work has been the furnishing of plans for bridges. In this work the Division examined 172 bridge sites, and furnished besides this many estimates on figures submited by letter, in all making a total of 238 estimated upon, from which 56 letters have been received that the bridges were constructed in conformity with the plans.

In the election last fall the amendment to the constitution allowing the state to appropriate money for the construction of roads was passed by a majority of 70,000, and it is expected that the Legislature now in session will pass a state aid law of some description. It is believed that this law will take the form of non-paid commission for the most part ex-officio, and that money will not only be appropriated for the construction of stone and gravel roads, but also for bridges and heavy grading operations on the more important roads of the state.

A Mine-Explosion and Mine-Rescue Station has been established at the College of Engineering of the University of Illinois by the United States Geological Survey, in co-operation with the State Geological Survey. The purpose of the station is to interest mine operators and inspectors in the economic value of such modern appliances as oxygen helmets and other resuscitation apparatus as adjuncts to the normal equipment of mines. The station also will concern itself with the training of mine bosses and others in the use of such apparatus. Its service is to be rendered gratuitously, and so far as possible to all in Illinois, Indiana, Michigan, West Kentucky, Iowa and Missouri, who may desire.

At the beginning of 1908 the entire railway system of Russia reached a length of 40,111 miles, having been increased during 1907 by 1,173 miles.

The U. S. government is to establish a Forest Service Laboratory at the University of Wisconsin.

Unclassified and General Articles

Note: This section is devoted to methods and cost articles on construction work not properly coming under any of the preceding classifications.

An Act to Establish a Civil Engineering Council and a State Board of Examiners of Civil Engineers in Pennsylvania.*

Section 1. Be it enacted by the senate and house of representatives of the commonwealth of Pennsylvania in general assembly held and it is hereby enacted by the authority of the same that upon the passage of this act the lieutenant governor, the state commissioner of highways and the state superintendent of public instruction shall constitute a civil engineering council of which the lieutenant governor shall be president who shall supervise the official actions of the board of examiners, hear all appeals from their decisions and charges against the probity of any member thereof, pass finally upon all examination papers of candidates for a license to practice as civil engineers, sign all licenses in conjunction with the board of examiners of civil engineers and prefer charges for dismissal for incompetency, failure to perform duty or dishonesty against any member of the board of examiners for civil engineers to the governor of the commonwealth. The civil engineering council shall meet at least twice yearly and always after an examination has been held by the board of examiners for civil engineers and shall receive as compensation for services rendered $100, as provided for hereinafter.

Sec. 2. The governor shall appoint after the passage of this act five recognized civil engineers, who shall constitute the board of examiners for civil engineers, who shall have actually practiced in their profession for a period of at least seven years or he may select as members of the board any professor holding chairs in civil engineering in any college or university of this commonwealth duly chartered under the laws of this state and having power to grant the degree of civil engineer. Their terms of appointment shall be as follows: One for one year, one for two years, one for three years, one for four years, and one for five years. The new appointee in 1910 and annually thereafter shall hold office for five years. All vacancies shall be filled for the unexpired term and the term of office of the appointees of the governor under this act shall begin on June 1, 1909, at which time the board of examiners shall organize and annually thereafter unless said date occur on Sunday, and in that event the reorganization shall be on the Tuesday following. At such organization and reorganization annually thereafter the board shall elect a president, secretary and treasurer. The board shall make such rules and regulations for its government and for the examination of applicants for licenses as civil engineers as shall to them seem proper. They shall be authorized to take testimony concerning all matters within their jurisdiction and the presiding officer of said board or any of the committees thereof may issue subpoenas and administer oaths to witnesses.

Sec. 3. Every applicant for a license as civil engineer shall make written application to the secretary of the state board of examiners for civil engineers on or before the first day of April and October and shall indicate in such application his full name and address, place of employment and duration of the same with whom employed together with a brief history of any engineering work of importance upon which he has or has had supervision or was detailed. When a sufficient number of applicants have filed their intention of taking examination, it shall be the duty of the president and secretary of the board to give notice in some of the leading papers of the commonwealth of the time and place for holding the proposed examination, together with the topics in which the said applicants shall be examined. All examinations shall be in writing. After the board of examiners have passed upon the merits of the examination papers of applicants for a license to engage in civil engineering they shall certify their conclusions and all papers to the civil engineering council. Should the latter body confirm the recommendations of the board of examiners, then such of the applicants for a license as shall have successfully passed the examination or may have been recommended for a license shall be granted same, which shall be issued by the secretary of the commonwealth upon the payment of a fee of $2. Candidates for a license if reexamined shall be given credit for any topics in which they successfully passed at a previous examination.

Sec. 4. Previous to the examination of any applicant for license as civil engineer he shall make payable to the treasurer of the board of examiners a certified check of $20, which sum shall accompany his application and shall go towards the payment of expenses of said board, and should any applicant fail in examination and be reexamined at some future time then the regular fee must be paid regardless of former payments. From the moneys in the hands of the treasurer of the board of compensation of the civil engineering council and all other expenses incident to said examination. Any residue must be equally divided among the board of examiners, provided that in no case shall the members thereof receive over $500 per annum. All unexpended balances shall be paid to the state treasurer annually on June 1 and shall go to the fund for the use of the public schools.

Sec. 5. This act shall not refer to persons who have graduated as civil engineers or bear a certificate of proficiency in civil engineering from any college or university of this commonwealth regulated by state charter or to graduates of colleges or universities of other states or countries which are recognized by the civil engineering council and the board of examiners as institutions of a high standard in civil engineering instruction. Neither shall the provisions of this act extend to any person who has for seven consecutive years practiced the profession of civil engineering in this state or to mining engineers making surface surveys in connection with their mine work. All persons classed under the latter provision shall give positive proof of their right to practice the profession of civil engineering and after due proof shall be awarded a regular license upon the payment of a fee of $10 to the treasurer of the state board of examiners.

Sec. 6. Any person practicing the profession of civil engineering within this commonwealth after January 1, 1910, who has not filed with the prothonotary of the county wherein he resides a copy of his diploma certificate of competency or his state license shall be guilty of a misdemeanor and upon conviction shall be fined $50 and upon conviction for a second like offense the defendant shall be sentenced to pay a fine of $100 to be collected in like manner, and upon conviction for a third like offense the defendant shall be subject to pay a fine of $200 and suffer an imprisonment of not less than 30 days and not more than 6 months and to be deprived of securing the license provided for in this act for a period of 5 years thereafter. The fines provided for herein shall be paid one half to the informer and one half to the commonwealth of Pennsylvania for the use of the public schools thereof.

Sec. 7. The term "civil engineer" as applied and used in this act shall mean any person skilled in the principles and practice of any department of engineering including surveying and profiling, and the words "civil engineering" as employed in this act shall be interpreted to mean that branch of engineering which relates to the construction or care of roads, bridges, railroads, canals, aqueducts, harbors, drainage and sewage works.

Sec. 8. All acts inconsistent herewith are hereby repealed.

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*A similar act for licensing engineers in Idaho was published in Engineering-Contracting for March 3, 1909.

The total mileage of government railways in the Commonwealth of Australia at the close of the fiscal year [illegible] was [illegible]

Catalogs Worth Having.

Engineers and contractors should have on file the latest catalogs of machines, tools and supplies that they use. In sending for catalogs reviewed or advertised in this paper, you will confer a favor on us if you will write direct to the advertisers and state that you saw the catalog mentioned in ENGINEERING-CONTRACTING. If you are in the market for tools, machinery or supplies, tell us and we will notify promptly the leading manufacturers.

No. 1131. **Plans for Concrete Residences.**—Universal Portland Cement Co., Chicago, Ill.

This very handsome pamphlet contains 19 designs for concrete residences, with descriptions and estimates of costs, submitted in a competition of the Chicago Architectural Club for prizes offered by the Universal Portland Cement Co. The rules of the competition are given and for each design a description and estimate of cost, a perspective view and first and second floor and attic plans. This pamphlet excellently demonstrates the adaptability of concrete to pleasing architectural treatment, and the company issuing it deserves commendation for the task which it has performed.

No. 1132. **Tests of Friction Clutches for Power Transmission.**—The Hill Clutch Co., Cleveland, O.

This is a reprint of the excellent paper read by Prof. R. G. Dukes at the last annual meeting of the American Society of Mechanical Engineers. Those who have not read Prof. Duke's paper will do well to secure this pamphlet. It is worth keeping on file.

No. 1133. **Tanks and Towers.**—U. S. Wind Engine & Pump Co., Batavia, Ill.

This 32-page pamphlet shows illustrations of a number of tanks and towers of various styles and gives tables of standard sizes of small storage tanks, railroad tanks, fire service tanks, tank roofs and steel towers. Details of hoops, joints, base elbows and of single-angle and double-angle towers are given.

No. 1134. **Derricks and Hoists.**—Superior Iron Works, Superior, Wis.

A set of circulars illustrating and describing derricks, steam scow winding gear, anchor hoist engines for operating dredge anchors or spuds, cable haulage and derrick engines and dredge deck engines for handling dump scows.

No. 1135. **Concrete Mixer.**—The Miles Mfg. Co., Inc., Jackson, Mich.

This circular describes the Simplex Concrete Mixer, which is claimed to combine the advantages of automatic feed of continuous mixers and of the principle of mixing of batch mixers. The machine is an interesting one and concrete workers should secure this circular.

No. 1136. **Reinforced Concrete Retaining Walls.**—The Concrete Steel Retaining Wall Co., Cincinnati, O.

This 21-page pamphlet describes the Bone Retaining Wall and presents estimates, drawings and arguments demonstrating its economy and efficiency as compared with plain concrete and masonry walls. The pamphlet contains some interesting data and should be kept on file.

No. 1137. **Air Hose and Hose Fittings.**—The Cleveland Pneumatic Tool Co., Cleveland, O.

A 4-page circular illustrating and describing air hose, hose couplings, hose nipples and hose menders. Contractors will be interested in the hose clamps and couplings which are described.

No. 1138. **Engineering and Drafting Instruments and Supplies.**—Keuffel & Esser, New York, N. Y.

The thirty-third edition of this catalog, which has just been published, is the largest yet issued by this well-known firm, and will be of interest to every engineer and architect. The general appearance of the catalog has been improved and it is handsomely bound. Interspersed throughout the book are illustrations showing for the first time the interiors of the general office and factory buildings at Hoboken, N. J., which the company now occupy, as well as glimpses of the stores in New York, Chicago, St. Louis, San Francisco and Montreal. An important change in the general arrangement of the catalog has been made by creating a special section for "drafting office furniture," which is now forming an important department among the goods manufactured. It would lead too far to enumerate the many additions made to the various lines of drafting instruments, surveying instruments, etc., but they will be readily noticed by those familiar with the previous editions of this catalog. The catalog contains some 540 pages and will be sent to engineers, free of charge, on application.

No. 1139. **Eclipse Concrete Mixer.** — The Standard Scale & Supply Co., 50-52 South Canal St., Chicago, Ill.

A 4-page circular describing this non-tilting batch mixer, for which an especially low charging arrangement is claimed. This feature is described as follows: "The material to be mixed is wheeled onto a low platform, charged into the drum and is drawn into the center by the charging blades as the drum revolves. Being very simple in construction, it solves the problem of low charging and does away with hoppers and other complicated devices used for conveying material, which always require considerable power."

No. 1140. **Boilers, Engines and Machinery.**—Wickes Bros., 90 West St., New York.

A monthly price list, 32 pages, issued by this company of the boilers, engines and other machinery offered for sale.

No. 1141. **Under-Feed Stokers.**—American Ship Windlass Co., Providence, R. I

A 40-page catalog, of neat and attractive appearance, describing and illustrating the Taylor gravity under-feed stoker. The construction and operation are shown, and attention is called to its many advantages, such as the saving in fuel, labor and other items.

No. 1142. **Buckets and Skips.**—Cockburn Barrow & Machine Co., 30 Church St., New York.

An 8-page catalog, well printed, devoted to the Lockwood automatic dump bucket and skip. These buckets are meant to be used with either derricks or cableways, and they are dumped by the man behind the engine.

No. 1143. **Concrete Measuring Machine.**—The Conveying Weigher Co., 90 West St., New York.

An 8-page circular, telling of the Trump measuring machine for proportioning materials for concrete. The machine does its work automatically and can feed the materials either into a mixer or a bin.

No. 1144. **Road Building.**—A. L. Barber Asphalt Co., 90 West St., New York.

A 34-page pamphlet, being an article entitled "The Best Road and the Right Way to Make It," by A. L. Barber. Advocates the building of a macadam road with a strip of asphalt pavement in the center to take the great volume of traffic.

No. 1145. **Aid to Shippers.**—Oelrichs & Co., Forwarding Dept., 5 Greenwich St., New York.

"Aid to Shippers" is the title of a 72-page book containing a quantity of information of value to all engaged in the export or import trade. It contains tables of foreign money and weights, measurements, tariffs, custom requirements and other data of great value. It is sent free on request.

No. 1146. **Packing.**—Greene, Tweed & Co., 109 Duane St., New York.

A catalog telling of the various steam packings manufactured by this company.

No. 1147. **Rain Gages.**—Ernest H. Du Vivier, 30 Church St., New York.

Bulletin telling of rain gages, a very necessary thing for engineers and contractors engaged in water supply work and hydraulic construction.

No. 1148. **Handling Explosives.**—Bureau of Explosives, 24 Park Place, New York.

A 70-page pamphlet, being the report of the chief inspector of the bureau for the safe transportation of explosives and other dangerous articles of the American Railway Association. Valuable information is given on the subject of storing and shipping explosives and showing causes of accidents. Copies can be had for $1 each.

No. 1149. **Pumps.**—Dean Bros.' Steam Pump Works, Indianapolis, Ind.

A small 64-page catalog describing and illustrating steam pumps of many kinds manufactured by this company.

No. 1150. **Street Flushing Machine.**—D. Connelly & Co., West St., Cleveland, O.

A 14-page, handsomely printed and illustrated catalog, showing the Connelly automatic street flushing machines, and telling why they are superior to similar machines and explaining the superior points of cleaning streets by this method of flushing over other methods now in use.

No. 1151. **Crushing and Road Building Machinery.**—The Good Roads Machinery Co., Kennett Square, Pa.

This 60-page pamphlet illustrates and describes the Champion line of road machinery, sold by the above named company. The Champion crusher and crusher outfits are described in great detail. Among the other machines illustrated are traction engines dump cars, road machines, and road rollers, as well as dump wagons, dump cars, scrapers and plows. This firm shows a very complete line of road machinery and the catalog should be of interest to road builders.

Personals.

Mr. M. B. Cowden has been re-elected City Engineer of Harrisburg, Pa.

Mr. Robert B. Dell has been re-elected Borough Engineer of Duquesne, Pa.

Mr. M. P. Mitchell has been re-elected Borough Engineer of Dunmore, Pa.

Mr. Walter B. Snow, Publicity Engineer, Boston, Mass., has been elected a member of the Corporation of the Massachusetts Institute of Technology.

Bedell & Jacoby, Drainage Engineers, of Kansas City, Mo., have been appointed engineers for the recently organized drainage district on Big Creek, in Johnson and Henry Counties, Missouri.

Henry Bausch, Vice-President of the Bausch & Lomb Optical Co., of Rochester, N. Y., died early this month at Augusta, Ga., after a long and painful illness. Mr. Bausch was 50 years of age.

Mr. H. P. Mobberly has resigned as Division Engineer of the Texas & Pacific Ry. and has opened an office at 304 South Jefferson St., Springfield, Mo., where he will engage in a general practice in civil and hydraulic engineering.

Mr. Henry M. Steele, who has for the past few years been with J. G. White & Co., Inc., Engineers and Contractors, 43 Exchange place, New York, as Chief Civil Engineer, has, on account of ill health, resigned and moved with his family from New York to Asheville, N. C.

Mr. William H. Adams and Mr. Robert J. Cummins have opened an office as Civil and Consulting Engineers in the Ford Bldg., Detroit, Mich. Mr. Adams for several years has been Chief Estimator of the Trussed Concrete Steel Co., of Detroit, and Mr. Cummins has been his principal assistant.

The Lindley-Kirkes Construction Co., of Oklahoma City, Okla., has been organized and has taken all work of J. E. Kirkes and will continue in the construction business on a larger scale than heretofore. The officers of the company are: T. H. Lindley, President; M. J. Lindley, Secretary-Treasurer; J. E. Kirkes, Vice-President and General Manager.

The Engineering Society of Wisconsin held its first meeting at the University of Wisconsin on Feb. 24, 25 and 26. The following officers were elected: President, F. E. Turneaure, Dean of the College of Engineers at the University of Wisconsin; Vice-President, McClellan Dodge, City Engineer of Appleton, Wis.; Trustees, for two years, B. F. Lyons, Assistant General Manager of the Beloit Gas & Electric Co., and E. P. Worden, Mechanical Engineer of the Prescott Steam Pump Co., Milwaukee; Trustees, for one year, E. Gonzenbach, of the Sheboygan Electric Light & Power Co., and E. R. Banks, City Engineer of Superior. These, as executive board, will elect the secretary later. The new organization will hold annual meetings hereafter.

Mr. Arthur M. Kinsman, heretofore Engineer of Construction of the Baltimore & Ohio R. R., has been appointed Chief Engineer of that road, succeeding D. D. Carothers, deceased. Mr. Kinsman is a graduate of the Worcester Polytechnic Institute, and began his railroad work in 1877 as a rodman on the Boston & Maine. In 1880 he was appointed Engineer of Surveys and Construction on the Chicago, Milwaukee & St. Paul, remaining there a year, when he was appointed Resident Engineer of the Illinois Central. He later became Division Engineer and then Superintendent of Construction. In 1895 he was appointed Chief Engineer of Construction and Maintenance of Way of the Wisconsin & Michigan. In 1899 he was appointed Engineer of Construction of the Baltimore & Ohio lines west of the Ohio river, with office at Akron, Ohio, and four years later was made Engineer of Construction of the entire Baltimore & Ohio system, with office at Baltimore, which position he held up to March 1, when he was made Chief Engineer.

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A Valuable Article on Reinforced Concrete Pile Work.

The value of detailed time records of operations is well illustrated in the excellent article on molding and driving reinforced concrete piles which we publish in this issue. A great many of the facts and conclusions on pile driving economics, for the presentation of which the article is notable, could not have been reached by any other method of study. To note only one item, note how the detail timing of delays in driving disclosed opportunities for increasing the number of piles driven by nearly 70 per cent, without any additional labor cost, but merely by doing away with wasted time. Other examples might be enumerated, but the intelligent contractor will discover them himself as he reads the article which we strongly advise every contractor to do. There has never before been published so good an article on reinforced concrete pile work.

The Findings of the Interstate Commerce Commission as to the Costs of Constructing the Northern Pacific and the Great Northern Railways and Its Decision in the Spokane Rate Case.

In our issues of April 15, 1908, and May 6, 1908, we gave detailed estimates of the cost of reproducing the Northern Pacific and the Great Northern Railways, as submitted by their chief engineers in the "Spokane rate case" before the Interstate Commerce Commission. In the same articles we gave some of the criticisms of these estimates by the chief engineer of the Washington Railroad Commission to whom this testimony was submitted in behalf of the city of Spokane, the complainants.

The Interstate Commerce Commission has just rendered a very important decision in this case, under which the Northern Pacific and the Great Northern are directed to make a reduction of 16 2-3 per cent upon all class rates from St. Paul to Chicago.

There are other important points involved in the decision, which we shall not go into, but, as indicating the probability that the Interstate Commerce Commission will itself undertake a valuation of American railways before long, we quote as follows from the report of the commission:

"This investigation conclusively shows that if any importance whatever is to be attached to the cost of reproduction in the establishment of railway rates, the valuation must be undertaken by the government itself. No individual has the means and no individual if he had the means could afford the expense of procuring even a rough estimate, accurate within reasonable limits, of the cost of rebuilding either of these defendant properties. In the present case we are impressed that the engineers of the defendants have proceeded in good faith, and the commissioners were fortunate in being able to consult their engineer at the hearing, a gentleman eminently well qualified to pass an opinion upon these questions, but even so we have little confidence in the reliability of the resulting conclusions. There can be no satisfactory knowledge upon this point until public authority makes a detailed valuation upon a uniform basis."

There can be no question as to the soundness of this conclusion.

The Northern Pacific Railway's chief engineer's estimate of the cost of reproduction was $416,000,000, including $50,000,000 for coal lands and $31,880,287 for right of way and $75,000,000 for terminals. The Commission rejected the item of coal lands entirely, as the coal mines are operated by a separate company which derives a profit from their operation. Mr. Gillette had testified that the construction and equipment estimates of the defendant were too high by $69,000,000, and that he had not sufficient knowledge of the lands to express an opinion. The Commission adopted a value of $325,000,000 for the Northern Pacific, which is equivalent to $56,000 per mile on its 5,810 miles. This is certainly very liberal, for it involves an acceptance of the railway's land values at practically its own figures. The capitalization of the Northern Pacific is $57,500 per mile of line.

The estimate of the chief engineer of the Great Northern Railway was $415,000,000 as the cost of reproducing the entire system, including $11,000,000 for equipment and $27,000,000 for right of way and $50,000,000 for terminals. Of this estimate the Commission says:

"The total above given includes $17,000,000 for contingencies, $3,500,000 for general and legal expenses, $37,000,000 for interest (during construction). The prices charged are in many instances too high and the method of computation not strictly accurate. On the whole, however, we are impressed that this estimate has been prepared in good faith and with great care. It was submitted to Mr. Gillette, engineer of the Washington railroad commission, already referred to, for his criticism and revision. In his opinion the estimate as given should have been reduced some $80,000,000 [He made no estimate of land values.—Editors] in all leaving a total of $335,000,000."

The estimate of the chief engineer of the Great Northern applies to 6,521 miles of main line, and is equivalent to $62,500 per mile. The commission scaled it down to $51,500 per mile. The Commission was unable to ascertain the capitalization of the Great Northern. We quote:

"After spending days in examining annual reports to this commission, the annual reports to stockholders, current accounts in financial journals, it is still impossible to say with any degree of accuracy what money has gone into the properties of the Great Northern system—either the 5,335

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miles which it now operates or the 6,523 miles which it controls and which are really a part of its entire property. *It would be difficult to devise a scheme better intended to confuse and to conceal than that employed in the development and operation of the Great Northern Railway System."*

The italicts are ours.

If additional arguments were needed to prove the necessity of constant government auditing of railway accounts, such instances as this furnish the last unanswerable reason.

The report on this "Spokane Rate Case" covers some 50 pages of reading that is of great interest to all who are studying the problems of government control of railways.

The Defeat of the Idaho Law Licensing Engineers.

The correspondent who furnished us the copy of the Idaho law licensing engineers which was published in a recent issue, writes us that the bill has been defeated. His letter indicating the cause of the legislature's adverse action is interesting, and we print it as follows:

> Sirs: The bill introduced in the Idaho House of Representatives licensing engineers was defeated. The gentleman who spoke against the bill characterized it as "forming a codfish aristocracy with the State Engineer at the head." Very truly yours,
>
> March 14, 1909. CITY ENGINEER.

(I) The reputable engineer needs protection from the competition of the incompetents and rascals within the profession.

(2) The public needs protection from the inefficient and defective works of rascally and incompetent practitioners of engineering.

"Reduced to their final analysis," as the Honorable Joseph Cannon would say, these are the claims for consideration of practically all acts providing for the licensing of engineers. The first reason is urged far more often than the second; it is the reason that impels most of the activity toward securing license laws for engineers, and it is not a reason that carries conviction of either the necessity or the benefit of such laws. The argument for licensing engineers, if it is to carry weight, must be based upon the claim of public welfare. It is not the fact that incompetents and rascals exist in the engineering profession that is of importance so much as it is the fact that their inefficient and defective works endanger the well-being of the public. Put another way, it is the quality of the engineer's work that affects public well-being far more than it is the character of the engineer himself. To our way of thinking it is, therefore, the engineer's work that should be "regulated" and not primarily the engineer himself. Legislation which looks toward establishing a board of review or of supervision of plans for public works has reason behind it and sound precedent to guide it.

Concrete and Reinforced Concrete Section

Note:—This section is devoted to methods and cost of constructing concrete and reinforced concrete structures. It will cover the selection, testing and proportioning of concrete materials; laboratory tests of concrete; concrete mixing, transportation and placing; fabrication and placing of reinforcement, and form construction and erection. It will also contain articles on new and interesting developments in the design of reinforced concrete.

Method and Cost of Molding and Driving Reinforced Concrete Piles for a Building Foundation in Cambridge, Mass.*

The object of this paper is to give a description of the design, construction and data on driving cast reinforced concrete piles for a foundation of the Boston Woven Hose & Rubber Co.'s new power plant in Cambridge, Mass. Detail times of the various elementary operations were taken on 20 of the piles during the driving with a view to determining the best methods of driving cast reinforced concrete piles and to compare piles of slightly different design and especially to analyze the times and costs for future estimates. The results obtained from these observations are recorded in tables forming a part of this paper; and from them curves of some of the piles, showing the penetration during the driving, are drawn to illustrate the different methods of driving and the obstacles encountered.

From the observations taken on this work the unit costs were determined as given by Table II, and also the following conclusions in regard to methods were drawn. Although these conclusions may not all be of general application because drawn from one set of piles, they are presented just as they were given in the original report upon the work as furnishing suggestions of general value:

Conclusions.—Arrange molding platform if possible so that butts of pile are placed to be drawn direct by pile driver.

Design butt so that pipe connection does not interfere with snatch ring. Place pipe connection so that hose can be connected before raising pile and supporting rope will not interfere with derrick hook.

If piles are made in cool weather and are to be driven in 30 days, strengthen concrete mix at butt by working some dry cement into it while ramming.

Use perfect rolls under driver to facilitate quick moving. The plan found best at Cambridge with the 4,700-lb. hammer was to begin driving by churning and water jet, using this method as long as possible. The chain connecting pile to hammer was then disconnected and driving began with hammer drop of about 2½ ft., increasing drop as driving became harder; 4 ft. may sometimes be used at the start.

In ground not too hard it may be advisable after completing churning to give the chain a slack for a ½-ft. drop, and raise pile a little with a jerk after each blow. This appears to be effective only in ground soft enough so that the pile can be readily raised, and as it takes time to adjust chain, is hard on engine, and tends to start head crushing, it is of very doubtful value.

As tip of pile should have good bearing on ground undisturbed by water jet, the water should be shut off before the pile is down to grade.

The 8x8-in. tip was found to be slightly preferable to the 10x10-in. tip in time of driving. The 2-in. jetting pipe gave the best results, and it is suggested for future use that this be reduced to 1 in. or 1¼ ins. for the last 12 or 18 ins. at the tip.

For piles of 30 ft. or less length the longitudinal reinforcement may be ¾-in. rods instead of ⅞-in., but for piles of over 30 ft. computations should be made so that the longitudinal reinforcement will be strong enough to stand the vibrating weight of the pile when it is being raised to the gins of the machine.

Design.—The piles as designed by Mr. Fox were made 30 ft. 6 ins. long, 14 ins. square at the butt end, and in general 9 ins. square at the tip. A number of soundings were taken at the site of the power house which indicated a fill of from 6 to 8 ft.; below this to a depth of 29 ft. 7 ins. to 31½ ft. from the surface, fine sand and mud (practically all may be considered sand); and below the sand a clay hard pan was reached which was tested to a depth of 13 ft. These tests, together with a consideration of the requirements, determined the length of the pile.

Of the 48 piles which were made, 6 were 8 ins. square and 6 were 10 ins. square instead of 9 ins. at the tip. The object of this variation in size of the tip was to determine which size gave the best results. The irregularity of water pressure proved a very great handicap to making accurate comparisons and also affected very seriously the results obtained during the actual driving of each pile. Enough piles were observed, however, to give fairly good averages.

Averages of the time of actual driving the piles with different sized tips give the following results, which indicate that the 8-in. tip is slightly preferable in time of driving. The variation in the character of the ground as well as the water pressure may influence in a measure the relative times

---

*A paper read Sept. 16, 1908, before the Boston Society of Civil Engineers by Sanford E. Thompson and Benjamin Fox, and published in the "Journal of the Association of Engineering Societies" for January, 1909.

TIME DRIVING PILES WITH DIFFERENT SIZED TIPS

Size of Tip In	Range in Time Driving Min	Average Time Driving Min
8	26 to 107	66
9	22 to 166	76
10	4[illegible] to 139	87

Piles were reinforced with four ⅞ in corrugated steel rods extending to within 2 ins. of the ends of the pile, and imbedded 2 ins from the face near the butt and 1½ ins from the face at the tip Loops of ¼ in corrugated bars were placed around the principal steel, spaced about 12 ins apart except near the butt, where the spacing was decreased to 4 ins., there being 31 loops in all. The butts of the piles were also extra reinforced, some with ⅜-in. and some with ½-in. rods, varying in length from 2 to 3 ft. A ⅞-in. rod about 5 ft long was imbedded in the concrete with a loop sticking out through the concrete near the top of the pile on one side for hooking with derrick

A galvanized iron pipe was cast in the center of the pile for the water jet. For experimental purpose the sizes of pipes were varied, being 2 ins., 1½ ins., 1¼ ins. and 1 in. To carry out the experiment still further some of the piles were made with one of the larger size pipes for about half the length of the pile and there connected with one of the smaller pipes which extended down to the tip

The times of driving piles with different sizes of pipe in the interior of the pile were plotted, but the variation in each due to other causes was so great that no practical conclusion could be reached. The results simply indicate that the pile with 1 in pipe took slightly longer to drive than the piles with larger sized pipe.

The friction of water running through pipe of small size is very great, so that it is known without experimenting that the largest size pipe which it is practicable to insert in a pile will give the least loss of head and therefore be the best. To increase the velocity of the water, and thus increase its power to loosen earth (note that it is the velocity, not the pressure, which is increased), the size of the tube should be reduced near the tip. The reduction must be made far enough from the tip of the pile to prevent clogging under heavy blows. There is no danger of the nozzle filling while the water is flowing freely, and therefore no danger while the pile is being churned down in the first few blows. The danger is apt to occur when the driving becomes hard and at the time the penetration per blow is so small that it would seem that a nozzle 12 ins long would be sufficient to prevent any material working up into the larger pipe. A 2 in pipe is probably as large as is practicable, and it is therefore suggested that this size be used to within 12 ins., or if preferred, 24 ins from the tip, and there reduced to 1 in.

Detail Operations During Driving—In order to correctly analyze such work as this and separate it into small enough operations to permit the adaptation of the times and costs to other jobs, very minute and exact records are necessary

The records were taken by Mr Thompson's assistant engineer, Mr William O Lichtner, with the aid of the decimal watches and the watchbook shown by Fig 1. When the pile drivers were about to start a new pile, each individual operation, such as moving pile driver, attaching rope to pile, pulling pile, raising pile vertically, and so on, was entered on the note sheet In many cases each one of these operations became separated into two or three parts by delays or additional operations occurring in

TABLE 1.—DATA ON CONCRETE PILES

(1) Pile No	(2) Date Made	(3) Date Driven	(4) Age at Driving	(5) Dimensions at Point	(6) Size of Pipe	(7) Depth Driven, Ft.	(8) Moving Driver Min.	(9) Placing Pile Min	(10) Time Driving Min	(11) Delays Before Driving Min (1)	(12) Delays During Driving Min (2)	(13) No of Blows	(14) Range in Drop Ft	(15) Last Blow Drop Ft	(16) Last Blow Penetration Inches
A	3-24-08	4-24-08	31	8" x 8"	2"	18.0	spc	109.5	191.4	58.0	87.5	697	1.0 to 4.0	5.5	[illegible] (3)
B		4-25-08	32			28.7	15.0	40.6	113.5	1.6	20.2	895	1.0 to 3.5	3.0	[illegible]
C	3-25-08		31			25.6	11.1	46.8	41.7	0.0	12.0	280		1.0	[illegible]
D			31		1½"	28.8	2.0	39.7	90.7	0.0	41.2	560	0.5 to 2.0	1.0	[illegible]
E			31			30.8	21.9	35.1	118.6	0.0	42.5	592	0.5 to 1.5	2.2	[illegible]
F		4-27-08	33			30.9	— 104.5 —		28.1	1.6	2.5	187	0.5 to 5.0	4.0	1
I	3-26-08		32	9" x 9"	1½"	32.0	90.0	28.7	142.8	0.0	17.0	392	0.5 to 5.0	4.0	
J			32		1½"	30.6	18.9	27.0	54.0	0.0	9.9	336	1.5 to 5.0	8.0	[illegible]
N	3-27-08	4-28-08	32		2" top 1½" bot	30.5	— 57.9 —		25.6	0.0	4.4	112	1.5 to 4.0	4.0	[illegible]
O			32		1"	30.5	70.4	22.3	108.1	0.0	12.0	646	0.7 to 6.5	6.5	[illegible]
P			32			26.5	26.0	12.7	176.6	0.0	24.0	1,160	3.0 to 9.0	8.0	[illegible]
V	3-30-08	4-29-08	30		1½"	31.0	50.0	15.3	69.2	4.6	6.8	509	1.5 to 5.5	5.5	[illegible]
W			30			30.5	5.0	15.1	128.8	0.0	12.6	939	0.7 to 6.0	6.0	[illegible]
X			30		2" to 1½"	21.5	— 63.9 —		78.8	35.6	10.4	610	0.7 to 6.0	6.0	[illegible] (3)
Y		4-30-08	31		1½"	30.5	— 69.5 —		32.1	0.0	3.0	255	1.5 to 5.0	5.0	[illegible]
Z			31			27.8	35.3	20.1	49.6	0.0	3.7	469	0.2 to 3.5	3.5	[illegible]
1			31			29.5	23.6	21.5	98.0	0.0	14.7	710	0.5 to 3.5	3.5	
2			31												
3		5-1-08	32					35.0	42.0						
4			32				43.0	12.0	43.0						
5			32				40.0	10.0	36.0						
6	3-31-08		31				— 29.0 —		60.0						
7			31				33.0	12.0	62.0						
8		5-2-08	32												
9			32					45.0	75.0						
U	3-28-08		34		2" to 1½"		— 25.0 —		137.0						
T			34		1½"		28.0	60.0	65.0						
S		5-4-08	36				54	0	78.0						
R			36				30.0	15.0	115.0						
Q			36				25.0	10.0	55.0						
M	3-27-08		37		1½		75.0	10.0	135.0						
H	3-26-08		38				22.0	8.0	78.0						
G		5-5-08	39		1"		12.0	5.0	85.0						
K	3-27-08		38				15.0	14.0	166.0						
10	3-31-08		35		1½"		105.0	15.0	50.0						
11			35				5.0	13.0	32.0						
12	4-1-08		31				20.0	10.0	45.0						
13			34				20.0	10.0	52.0						
14			34				8.0	10.0	70.0						
15		5-6-08	35				— 38.0 —		112.0						
16			35	10" x 10"			5.0	10.0	75.0						
17			35			30.2	20.0	25.0	85.0	0.0	27.8	568	2.0 to 8.5	8.5	[illegible]
18			35			30.2	40.0	35.0	130.0	0.0	48.8	1018	2.5 to 20.0	10.0	[illegible]
19			35			30.3	40.0	15.0	110.0	0.0	15.4	740	1.0 to 6.5	6.5	[illegible]
20		5-7-08	36		1"			10.0	50.0						
21	4-2-08		35		1½"		10.0	10.0	75.0						
22			35				10.0	5.0	82.0						
L	3-27-08		41	9" x 9"	1"		28.0	20.0	190.0						
Av			33.5				29.0	23.0	83.0	5.1	21.3	589			
Av	during last 4 days						27.0	13.0							
Av	on 16 piles under 60 min								44.0						

(1) Included in Column (9). (2) Included in Col. (10). (3) Head smashing.

the midst of them, and these delays were also recorded with the time.

When the driving was actually begun, the number of blows of the hammer was recorded by a pocket mechanical counter, and the time required for each blow or for a series of five blows was entered on the note sheet, together with the height of the drop and the penetration, the latter being read from a scale painted on the gins of the pile driver. Of course any stops during the driving were noted, with the length of the stop and the cause.

[The full log of these records is given in the original paper, but is omitted here because of its great length. A summary of the detailed data is given in Table I and is amply complete for all but minute analyses.—Editors.]

Methods Employed in Making Piles.—The method of construction is as follows: A 2-in. platform of rough plank is built on ground of sufficient area to hold all of the piles. On this platform chalk lines are struck and V strips to form a 1-in. chamfer nailed so that the lines of the piles are about 6 ins. apart, alternating points and butts. The casting of the piles with tips and butts alternating is economical of space, but where the piles are cast so as to be handled directly by the pile driver, without any intermediate handling, it is best to cast them all with the butts toward the machine on account of the saving of time in getting the pile in the gins. Two 8-in. unplaned (to assist in skin friction) spruce planks form the sides of each pile. The piles are made in lots of about five. The outside form is cleated with 2x4's, and the other sides have the plank simply set on edge with pairs of wedges between them. There are seven cleats or wedges in the length, and seven pieces 2x4 nailed across the top of each. After setting the plank sides, beveled pieces are nailed to locate the upper surface and form a chamfer.

Steel is wired together on a table consisting of plank on three horses. The reinforcement when made is suspended in form by two wires attached to each of the 2x4 cross pieces.

Two days were usually allowed before striking the forms.

GANG MAKING PILES.

One foreman		
2 laborers on miscellaneous work..	@	$0.25
4 laborers wheeling and mixing concrete	@	0.25
2 laborers ramming.................	@	0.25
4 carpenters	@	0.43¾
4 steel men (2 carpenters and 2 laborers), averaging		0.40

The concrete gang mixed and placed concrete in 10 piles in 10 hours. It took 4 carpenters 3¾ hours each, or a total time of 15 hours, to set up sides for 5 piles (10 sides), and 4 carpenters ½ hour each, or a total of 2 hours, to take down the sides for 5 piles. It took one carpenter and one laborer 10 hours each to wire up 5 reinforcing frames and place them in form ready for concreting.

Each frame was composed of four ⅞-in. rods in corners running full length of pile, ¼-in. hoops 12 ins. on centers except for 2 ft. at the top, where hoops were spaced 4 ins. on centers. Four additional ½-in. rods 2 ft. long and a ⅞-in. bent rod for hooking the pile were placed at this same end. A 1½-in. pipe was also placed in the center of the pile.

The concrete was mixed by hand in the proportion of 1-2-4, using ¾-in. trap rock, the sand and cement being first made into a mortar and the stone added. A thorough mix is of course essential. Mixing was started in March, precautions being taken at night against possible frost and the piles wet down every day for two weeks.

The age of the piles when driven ranged from 30 to 41 days, the larger part of them being nearer the shorter age. The first pile was molded on March 24 and driven on April 24, and during this period the temperature was low, averaging between 40° and 50° F., so that the piles had not attained nearly their full strength. After the driving was commenced the weather became much warmer, and the piles after the first few were noticeably harder and entirely satisfactory, even although the age was practically the same, that is, about one month. The first pile driven lost its water pressure when about 6 ft. below the surface, and during the process of driving, which reached 700 blows, it is probable that it broke when about half-way down. The head of this pile was badly crushed, whereas subsequent piles which had hardened more thoroughly because of the higher temperature were uninjured, even with a similar number of blows and higher drops of the hammer.

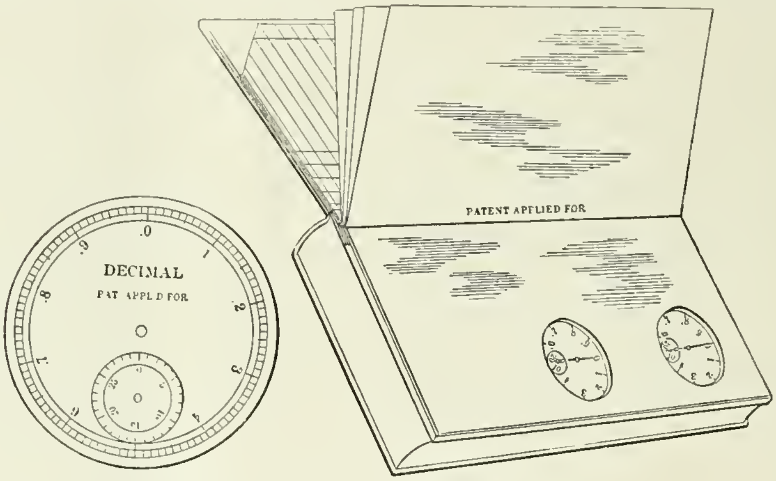

Fig. 1—Decimal Dial for Stop Watch and Watch Book.

It may be said, therefore, that a period of one month for seasoning piles is sufficient during, say, the months between May 1 and October 1, but during the colder months a longer period should be allowed unless artificial heat can be used to hasten hardening.

Pile Driver and Hammer.—It was decided, after a careful investigation of records of concrete pile driving both in this country and Europe, to use a 4,700-lb. hammer. With a view to the use of the heavy hammer and the side strains brought to bear on the machine by the dragging of the piles from the casting platform, a special driver was built. The driver was made as follows:

Long leaf hard pine was used throughout. The bed timbers were 8x10 ins., 18 ft. in length, the gins 8x8 ins., 42 ft. long. The braces of 8x8 ins. timber were run from the bed timbers to the head of the machine with intermediate braces and ties to give the necessary rigidity. The sheave was of extra heavy pattern and the whole framework was bolted up and tied together with rods. The cushion head, which was perhaps the most essential item, as it was desired to avoid fracture of the pile from the blows of the 4,700-lb. hammer, consisted of a plate iron collar 16 ins. square on the inside and 3 ft. in height, which incased an oak block 16x16x18 ins. on to the bottom of which six thicknesses of rope and four layers of rubber belting were nailed. The cushion head was held in place in the gins of the machine by four perpendicular pieces of oak on the outside of the collar and bolted through the incased oak block. A 25 h. p. Lambert engine was used and a single block for hoisting and churning the piles.

The water for jetting was furnished through a 2½-in. Bay State hose, using a compound piston pump having 7x12-in. high pressure, and 12x12-in. low pressure cylinders, and a capacity of 100 gallons per minute. This was the most unsatisfactory part of the entire work, the water pressure being variable and uncertain and 125 lbs. the limit of pressure obtainable at the pump.

Driving Piles.—The usual process of driving consisted, after moving the pile driver, in hooking and dragging the pile and lifting it to place and attaching the hose, or attaching the hose first and then hoisting.

As already shown the casting of the piles with tips and butts alternating is economical of space, but where the piles are cast so as to be handled directly by the pile driver, without any intermediate handling, it is best to cast them all with the butts toward the machine on account of the saving of time in getting the pile into the gins of the machine. When the pile is cast with the butt end toward the machine the pile can be lifted directly into the gins, while, when the pile is cast with the tip end towards the machine, it must be chained and dragged in front of the machine before it can be hooked in the usual manner and lifted to place.

Care must be taken when making the pile to place the hook for hoisting in relation to the projecting nozzle for jetting so that the hoisting rope will not foul the hose when the pile is being raised into position. To facilitate setting the pile into the gins, a crutch of 1-in. iron was made with a 12x12 in. square key at one end with a long handle to replace the peevy or cant dog ordinarily used for wood piles. As soon as the hose was attached and the pipe in place, the water was turned on and the pile usually penetrated for a short distance without the hammer. The hammer was then placed on the cushion and the pile sank further to a depth depending upon the nature of the fill. Next the hammer was attached to the pile with a chain and the churning commenced. There was enough play in the chain connection between the hammer and the pile to give about a 10-in. blow of the hammer each time the pile was lifted. When this churning became ineffective, the chain was disengaged and the pile was driven with blows in the usual manner.

GANG ON PILE DRIVING.

One foreman at $0.50 per hour	$ 4.00
One engineman at $0.50 per hour	4.00
One pump man at $0.25	2.00
Seven men at $2.50 per 8 hours	17.50
Total gang per 8 hours	$27.50

In addition to this gang 2 carpenters were called in occasionally for repairs, and 2 other laborers were busy most of the time in connection with cutting off piles, digging holes and odd work.

Gross Times Driving.—For convenient ulated in Table I, together with some of reference gross times driving piles are tab- the more important details. The times, for example, are separated into "Moving Driver," "Placing Pile," "Driving" and "Delays", and the "Number of Blows," the "Range in Drop" of hammer, and the drop and penetration under "Last Blow" are also given.

About half of the delays in Columns 11 and 12 are avoidable. It will be seen that the total average time per pile is 2 hours and 15 minutes, of which 29 minutes is moving driver, 23 minutes placing pile and 83 minutes driving. This corresponds to an average of 3½ piles per 8 hours, which agrees with the time that can be figured directly from the beginning to end of the job. As the men became more expert in moving the driver and placing the piles, it was possible to reduce the time to 1½ hours, as shown by the average during the last four days. Even this includes about one half hour moving pile driver, which was unnecessarily long because of imperfect rolls.

The time driving was greatly increased by the poor water pressure. Taking an average of 16 piles whose time was less than 60 minutes, and which, therefore, might be assumed to have gone down fairly well, the time during the driving was 41 minutes, thus giving a total of 1 hour and 24 minutes per pile, or 5.75 piles per day instead of 3.5 piles per day.

It therefore may be assumed on another job of similar character that an average of at least 5¾ piles may be driven per day. By using perfect rolls, molding piles with butts toward pile driver, and using good water pressure, this number may be still further increased. From a study of the individual items, times may be selected and estimates made which will apply to other locations and other conditions.

Instances of Hard Driving.—One of the first piles that was driven probably struck a large bowlder at 18 ft. below the surface. The pile was given 735 blows, using drops of the hammer of from 18 to 30 in. At this stage the head was so badly crushed that the driving was stopped and the projecting portion of the pile cut off. To see what effect this tremendous pounding with a 4,700-lb. hammer had on the pile, after squaring off the crushed head it was sent to the Watertown Arsenal to be tested. The Arsenal report was as follows:

TESTS BY COMPRESSION. CONCRETE PILE NO. 13,822.

Length, 9 ft. 3 in.
Size of butt, 12.9 in. by 13.75 in.
Size of tip, 11.15 in. by 11.75 in.
Weight, 1,458 pounds.
Cross-sectional area (smaller end), 128.59 sq. in.
Ultimate strength, 497,000 lb. = 3,865 lb. per sq. in.
Remarks: Pile failed at smaller end, opening oblique and longitudinal cracks.

Attention should be called to the fact that the pile failed at the smaller end and not at the end receiving the hammer blows. This indicates that the pile was not materially damaged by the severe hammering it received, except at the immediate point of contact. An examination of tests of reinforced columns at the Watertown Arsenal shows, for columns of the same proportions of concrete and same age, and reinforced with four longitudinal rods varying from ¾ in to 1⅛ ins. a range of 2,000 to 3,000 lbs per sq. in. based on the total cross section of the concrete and steel. It will, therefore, be seen that notwithstanding the severe treatment of the pile in driving, the ultimate strength was considerably higher than the average strength of similar columns. Evidently the strength of the pile was not appreciably affected by the driving or by the crushing of the head.

Cost.—The costs of the materials and the labor are tabulated in detail in Table II. The labor costs are taken from the timekeeper's record, but are sufficiently subdivided to be useful for other jobs of a different character. The items which vary directly with the number of piles are separated from the costs which are independent of the number of piles, but must be applied to any job as a constant expense. Only a few items depend upon the character of the ground.

The lumber for the forms (except the platform) is assumed to be a constant for any job, because it can be used over and over. The size of the platform must vary with the number of piles.

The pile driver for any one job is figured at 25 per cent of the initial cost for depreciation and interest, but the cost of repairs is included in the items which vary with the number of piles.

The costs which are variable are given per linear foot of pile for subsequent use. It will be seen that the total cost per linear foot of pile on this particular job was about $1.63. If the length of piles differed greatly from those given, it might be necessary to still further separate the cost to provide for this.

TABLE II.—COST OF DRIVING PILES ON B. W. H. & R. COMPANY JOB.

	Total costs	Cost per linear foot of pile
(1) 6,000 ft. B. M. plank for platform @ $0.25 (Lumber cost $25 per thousand and assumed to be used four times.)	[illegible]	[illegible]
(2) 350 ft. B. M. for chamfer @ $30	[illegible]	[illegible]
(3) 25 lb. spikes for platform @ .03		
(4) 20 lb. 9d. @ .03		
(5) 8 lb. 4d. @ .04	1.67	0.0011
(6) 50 tons crushed stone @ $1.50	75.00	[illegible]
(7) 18½ yd. sand @ $1.00	18.50	0.0126
(8) 69¼ bbl. cement @ $1.82	126.49	[illegible]
(9) 192 pcs. ⅞ in. by 30 corrugated bars, 15,333 lb., @ 2.65c	406.32	0.2670
(10) 34¼-in. bars, by 48 piles by 5 ft. 0 in., 1,958 lb. @ 3.00c	58.74	[illegible]
(11) 8,160 ft. No. 14 wire 163 1-5 lb., @ $0.04½	[illegible]	[illegible]
(12) 4 pcs. ½-in. bars by 48 piles by 2 ft. 6 in. 480 ft. = 408 lb., @ $2.85	11.62	[illegible]
(13) 48 2-in. nipples, 12 in. long, @ $0.15	7.20	[illegible]
(14) 48 2-in. by 1½ in. ells @ $0.12	5.76	0.0039
(15) 1,440 ft. g. i. pipe @ $3.51 per 100	[illegible]	0.0346
(16) 48 hooks, @ $0.25	12.00	[illegible]
(17) Bending and placing reinforcement	[illegible]	[illegible]
(18) Labor on pile platform	[illegible]	[illegible]
(19) Labor on forms	[illegible]	[illegible]
(20) Labor on concrete	111.07	[illegible]
(21) Superintendence	[illegible]	[illegible]
(22) Pile driving labor	[illegible]*	[illegible]†
(23) Cutting slot in tip of pile	[illegible]	[illegible]
(24) Repairs to pile driver and cushion	[illegible]	[illegible]†
(25) Cutting off broken piles	[illegible]	[illegible]
(26) Rent of engine	[illegible]	[illegible]
(27) Superintendence	42.00	[illegible]*
Total cost	$[illegible]	
Cost per ft. varying with number and length of piles		$1.1705
Items Constant for Each Job.		
(28) [illegible] ft. B. M. plank for pile sides @ $25	$[illegible]	
(29) [illegible] ft. B. M. plank for ends @ $25	[illegible]	
(30) Pile driver 25% of $[illegible]	[illegible]	
(31) Getting ready, 2 days @ $30	60.00	
(32) Teaming, pile driver etc.	[illegible]	
(33) Removing driver	34.61	
Total cost per job	$[illegible]	[illegible]
Total estimated net cost per lin. ft. if job has 48 piles		$[illegible]
Add 25% for pumping, connections, contingencies and profit		[illegible]
		$1.63

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*After deducting $60 assumed as constant "getting ready."

†Only items affected by character of ground.

A study of the various items taken in connection with a study of the detail times suggests various places where the cost may be altered for other jobs.

For example, an inspection of the costs shows that the cost of the reinforcing steel is over one-third the cost of the piles. From the fact that piles withstood the severe usage given by the pile driving, it is probable, if the piles are not over 30 ft. long, that ¾-in. steel instead of ⅞-in. could be used for the corner rods, with extra reinforcement near the butt, as in the present case. The size of these rods can be determined by figuring the stress in them during the process of raising the pile to place. The pile is then a beam supported at the ends and carrying its own weight, which must at least be doubled to provide for swaying incident to the raising. The cost of the item of steel and labor would in such cases be varied accordingly.

The labor on concrete appears large, and might probably be reduced on another similar job from $111 to about $74. This is based on the fact that, while on the average only 6 piles were made, toward the latter part of the making 9 piles were made on one day and 10 piles on another, so that an average of 8 piles should be possible with the given gang. This is especially probable because the cost of making and placing the concrete was $2.32 per pile, or $2.25 per cu. yd., whereas the writer's data on hand mixing indicate that the cost should not have exceeded $1.50 per yd.

With reference to the time and cost of the driving, it must be taken into consideration that the job was a small one, only 48 piles being needed; that the work was of an untried character, and also that the conditions were unfavorable, especially as regards the water pressure. On a large job, in ordinary ground, where large stones or obstructions are not likely to be encountered, the number of piles driven per day should be greatly increased. A study of the detail log of the driving tests and a comparison of these times with detail records taken on other jobs, indicate that the average time per pile driven with the aid of a water jet may be easily reduced to one hour, while if the ground is very soft, the average time per pile, including the moving of the driver, need not be over 40 minutes. One hour per pile corresponds to 8 piles per eight-hour day, instead of 3½ piles per day. The estimated time on the items near the foot of the cost table, which is inversely proportional to the total number of piles given, would be decreased on a job having 200 piles from $0.139 to $0.035 per foot of pile. This, together with the reductions noted above, and the assumption of 8 piles driven per eight hours, would bring the estimated cost per linear foot down to $1 net, or, with 25 per cent allowance for pump hose connections, incidentals and profit, to $1.25 per linear foot. In soft ground, and where conditions are specially favorable, a still lower estimate is possible.

A few of the items, such as the nipples and short bars, are constant per pile, that is, are independent of the lengths of the pile, so that in a close estimate for longer or shorter piles they should be separated out or allowed for by inspection.

As it assumed in the estimate in the last column that 5¾ piles are driven in 8 hours, the total cost for harder or softer ground can be estimated by assuming the number of piles to be driven per day and varying the items marked with a † accordingly.

Records of six of the typical piles are plotted and the curves are shown on the diagram (Fig. 2).

The full curves in Fig. 2 show the portion of the driving where the water pressure was on and the dotted lines the driving after it had been cut off by the filling of the pipe at the tip of the pile. This stoppage was not necessarily due to the design of the pile or to the method of driving, but chiefly to the insufficient capacity of the pump.

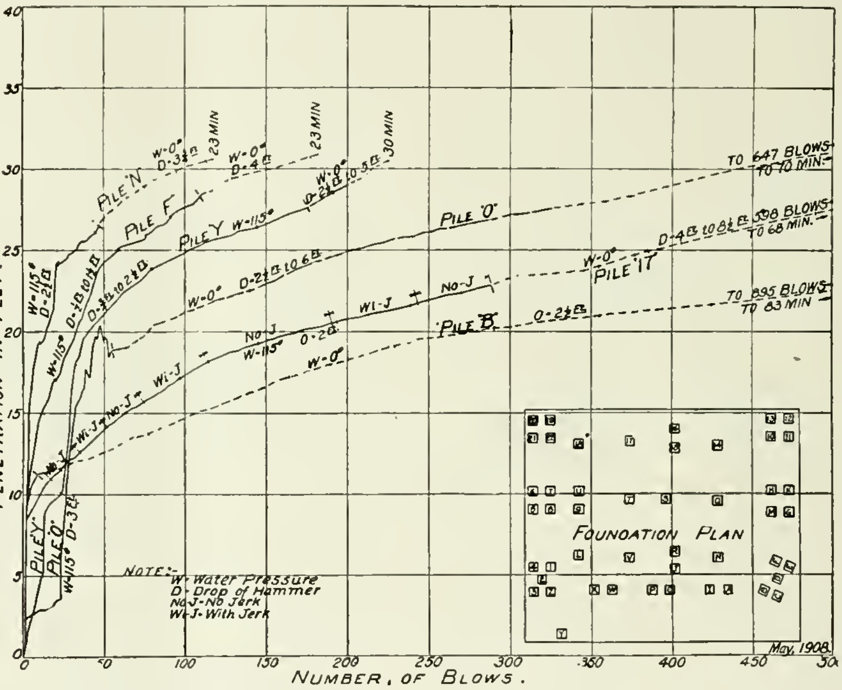

Fig. 2—Typical Penetration Curves for Reinforced Concrete Piles.

The flattening out of the curves indicates difficulties in driving, usually because of the poor water pressure. In certain cases irregularities indicate the striking of obstructions, and when the pile is slightly jerked ground is lost instead of gained.

Curves of piles *N*, *F* and *Y* are given to show good driving, the pressure remaining on most of the time, and the total net time, omitting all unnecessary delays, being from 23 to 30 minutes.

Piles *F* and *Y* show also that if a greater drop of hammer had been used at the start they would probably have approached nearer the *N*.

In driving pile *N* at 24-ft. depth, the hammer was allowed to just tap the top of the pile with no impact, and the pile being slightly churned, the loss of progress is shown by slight drop in curve. Then by increasing the height of the blow it started down again. Time, 23 minutes with 118 blows.

On pile *F* they first began jerking the pile after each blow, and this method appears to be affective provided ground is soft enough to actually lift pile readily. In hard ground it is ineffective. Drop of hammer was increased from 0.5 ft. to finally 4 ft. Time driving, 24 minutes with 185 blows.

Pile *Y* was not churned or lifted after first blow or two, but went down with light blows. Time, 30 minutes, 225 blows. Pressure good.

The curve of pile *B* is given to illustrate hard driving, due to lack of water pressure. The water pressure stopped at 11½-ft., as shown by the sudden break in curve at this point. Total time driving pile was 83 minutes with 895 blows.

In the curve of pile *O* there is an interesting break at the depth of about 20 ft., where an effort was made to assist the pile by churning or jerking, and ground was lost by doing so, and the pipe was also allowed to plug. As soon as the hammer was allowed to drop in the usual way the penetration began again, but 647 blows and 70 minutes by net time were required to carry it to its full depth. At a depth of 2½ ft. an obstruction was met, as indicated by the curve, and a small broken piece of timber came up beside the pile. Another reason for the flat pile of curve *O* is that the ground was usually hard.

Pile 17 was driven in an experimental fashion to determine the effect of the jerk at the end of each blow. The curve is uniform throughout, showing that this jerk is absolutely ineffective in hard ground. In this pile, as noticed, the height of drop was increased to 8½ ft.

Earth and Rock Section

Note: This Section is devoted to methods and costs of excavating earth and rock and building embankments. It will cover the grading of roads and railroads, diking and canal work, dredging, building reservoirs and earth dams, sewer and water pipe trenching, quarrying, etc.

Method and Cost of Quarrying and Crushing Rock Ballast at the Hog Mountain Plant of the Delaware, Lackawanna & Western Ry., with Some Costs of Ballast in Track.*

Early in 1905 the company acquired by purchase near Boonton, N. J., a granite quarry and crusher plant, together with other equipment in the way of cars, machinery, etc., that were utilized by a contractor in connection with the construction of a large masonry dam for a reservoir. This work having been completed by the contractor, the Lackawanna Railroad Company acquired about 3 miles of railroad running from its main line to the quarry plant, together with about 56 acres of ground, tracks at crusher plant, etc. In adapting this plant to our use and rearranging the tracks and crusher layout to meet our requirements, we expended at the outstart $21,904.33, and sold from the contractor's outfit certain equipment not required by us, which sale netted us $18,159.31, making the net cost to us of the quarry and plant at the time we started operating the crusher $26,245.02.

The material obtained from this crusher plant is a very good quality of New Jersey granite, weighing 2,795 lbs. per cu. yd. of crushed stone.

The quarry was well opened up when we acquired it from the contractor, and the face of the quarry has a depth of from 20 to 60 ft. and a length of about 2,200 ft. The stripping on top of the quarry will average about 2½ ft. The crusher machinery was manufactured by the Allis-Chalmers Co., and consists of one No. 8 and one No. 6 crusher, with a large bucket conveyor for conveying the broken stone from the crusher to the screens. There is one large 48-in. diameter screen, consisting of three sections, each 4 ft. in length, with ringings from ½-in. to 2½ ins. in diameter and a dust jacket for separating the materials. Materials which pass through the ½-in. ringing are not used for track ballast. The ballast product is conveyed on a Robbins belt conveyor and deposited into a system of bins; the finer material and dust pass directly over the dust jacket into the dust bin. The percentage of fine materials, i. e., dust and ¼-in. stuff, runs from 12 per cent to 14 per cent of the total output. The grades of tracks at the crusher plant are so arranged as to handle the cars after being placed by gravity. There is a powder magazine located on the property which has a storage capacity for about 10 tons of powder and explosives. There is also a water system for the boilers and a sprinkling plant to keep down the dust. The maximum grade of the track connecting our main line with the quarry is 3 per cent ascending to the quarry, and in handling our ballast we have been utilizing a locomotive which will handle 14 empty Rodger ballast cars up this 3 per cent grade. The larger part of the stone is handled from the quarry to the crusher plant by means of a derrick system, the face of the quarry being located quite close to the crusher plant. We have in use 6 large derricks with 90-ft. masts, which, with 6 hoisting engines operated in connection with the derrick system, handle the stone in large stone boxes. The stone is quarried from the top of the face by a stepping system. To pass into the No. 6 crusher the stone has to be broken up in sizes from 16 in. to 20 in. The breaking of the material is done with a system of block hole drills, placing holes from 6 ins. to 12 ins. apart, depending upon the size of the stone to be broken. We use from 3 to 6 block hole drills per day in breaking up the larger stone and some of the smaller stones are sledged instead of being block holed. In addition to the derrick system at this plant we also have a car system, by means of which cars loaded with stone from the quarry are dropped by gravity to the crusher. These cars have from 12 to 16 cu. yds. capacity, and when the cars reach the crusher plants are dumped by one of the derricks. The bottom of these cars is constructed of wood and metal, with a chain attached, and the false bottom of the car is picked up on one end by the derrick, and the stone dumped by this means without manual handling. After the cars have been dumped at the crusher they are returned to the quarry by a haulage system, operated by a hoisting engine. The stripping from the top of the quarry is disposed of by piling it back from the face of the quarry. In operating the quarry and crusher we have employed an average of 125 men, including rock men, drill men, engineers, mechanical men and laborers required at the quarry and crusher. We employ two blacksmiths for handling the drill work and a pipefitter for taking care of the steam-pipe system and steam drills. One mechanical foreman with the necessary help has charge of the crushing plant and one general foreman has charge of the quarry. One engineer handles the engine in the crusher plant and one fireman does the firing. We also utilize a 150-HP boiler for generating steam for the drills, and in addition to this we have two 150-

TABLE I. COST OF QUARRYING AND CRUSHING BALLAST, HOG MOUNTAIN CRUSHER DELAWARE, LACKAWANNA & WESTERN RAILROAD COMPANY.

Month and Year	Quarrying Stone. Labor.	Supplies.	Output.	Cost per cu. yd. for quarrying, cts.	Crushing Stone. Labor.	Supplies.	Output.	Cost per cu. yd. for crushing, cts.	Cost per cu. yd. quarrying and crushing.	Additional expense at plant—labor, placing derricks, etc.	Total cost	Total cost per yard, cts.	Average No. yards per day.
May, 1905	$2,469.54	$196.73	6637	46.2	$368.55	$226.00	6637	8.9	55.1	$1,068.10	$4,728.92	72	216
June, 1905	3,338.65	229.02	7048	50.6	377.40	157.97	7048	7.6	58.2	741.30	4,844.34	69	271
July, 1905	3,128.65	374.75	6267	55.9	317.18	94.25	6267	6.6	62.5	384.31	4,299.17	59	241
August, 1905	4,029.45	429.63	8722	51.1	368.55	94.25	8722	5.3	56.4	230.17	5,152.05	59	323
September, 1905	3,403.40	470.15	7017	55.2	361.70	104.25	7017	6.6	61.8	143.57	4,483.07	63	270
October, 1905 ...	3,149.03	388.88	6321	56	359.40	94.50	6321	7.2	63.2	168.35	4,160.16	66	243
November, 1905	2,988.76	338.58	6219	47.9	266.64	94.50	6219	5.8	65.1	116.00	3,917.98	67	235
December, 1905	2,638.77	395.55	5882	57.5	351.17	94.50	5882	7.6	53.7		3,338.49	53	249
January, 1906	1,119.80	146.13	3233	39.2	150.26	52.35	3233	6.3	45.5		1,467.54	45	260
April, 1906 .	3,339.96	534.42	7516	51.5	315.00	185.72	7516	6.7	66	592.16	4,967.56	66	301
May, 1906	3,958.95	657.98	11594	40	393.73	177.54	11594	5	50	573.85	5,763.05	50	429
June, 1906 ...	4,157.54	806.95	10622	47	355.00	212.45	10622	5	52	.....	5,527.91	52	409
July, 1906	4,178.91	783.78	10894	45.5	374.18	261.01	10894	6	52.5	.	5,597.88	52	436
August, 1906 . .	4,335.26	681.47	10183	49	379.68	236.41	10183	6	55	...	5,622.82	55	377

Note: Total average cost for quarrying, 49.04 cts. per cu. yd.; total average cost for crushing, 6.47 cts. per cu. yd.; total average cost per cubic yard, 55.51 cts. Plant not in operation in February and March, 1906.

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*Description by Mr. Lincoln Bush, Chief Engineer, D., L. & W. Ry., embodied in report of Committee on Ballasting, American Railway Engineering and Maintenance of Way Association.

HP. boilers for furnishing the balance of power for the derricks and at the crushers.

We started operating the quarry and crusher plant in May, 1905, and Table I is a detailed monthly statement of the cost of operations at this plant from May, 1905, to August, 1906, both inclusive. The plant was shut down on January 15, 1906, and operations resumed in March, 1906. The detailed statements of the cost of quarrying and crushing stone at this plant have been carefully kept and are reliable as to the cost as well as to output. The cost includes the quarrying and crushing, and includes the material loaded on cars at the bins.

We have used the crushed stone from this plant at various points along our line on the Morris and Essex Divisions, and during the present season we put on a ballast gang for ballasting a 4½-mile section of double track located between Hopatcong and Wharton, N. J.

In handling the ballast on this 4½-mile section we had an average of 31 laborers at 14 cts. per hour per day of 10 hours and one foreman at $75 per month. In addition to the regular ballast gang we had 8 section laborers on the 4½-mile section that were employed in digging out, changing ties, placing drain tile and filling for changes in alinement and easement curves. The amount of ballast used on the 4½-mile section of double track was 28,458 cu. yds., or an average of 6,324 cu. yds. per mile of double track. The average distance which the ballast was hauled from the crusher to the section ballasted was 13 miles. On the 4½-mile section of track ballasted there was a total length of curve line of 1.56 miles and a total length of tangent of 2.94 miles. We used in this work 24 Rodger ballast cars, and in figuring the cost of transportation the cars were placed at a value of $600 each. Our records show a cost of 5½ cts. per cu. yd., covering transportation charges, interest on the Rodger ballast cars valued at $600 each at 5 per cent. plus interest at 5 per cent on the net investment of the quarry and crusher plant. The cost for quarrying, crushing and loading cars at the crushing plant was 55 cts. per cu. yd.; the cost of placing ballast under track, including lining, surfacing and dressing, was 20½ cts. per cu. yd., making a total cost per cubic yard of the ballast in the track of 81 cts. for the 4½-mile section above described.

On the west end of our Buffalo Division we have an accurate record of the cost of 27,120 cu. yds. of crushed limestone ballast put in on a stretch of double track during the season of 1906. For this work we purchased the crushed stone delivered to us in our own Rodger ballast cars at an average cost of $0.6017 per cu. yd., and received an average of 222 cu. yds. per day, the quarry being located on our own lines. Thirty Rodger ballast cars were used for this work and the average haul was 13.4 miles. The ringing used in preparing this ballast was from ¾-in. to 2½ ins. diameter and the stone weighed 2,410 lbs. to the yard. As above stated, we received on an average 222 cu. yds. per day, and a larger quantity per day would have reduced the cost per yard somewhat. In comparing this cost with the cost of ballasting with materials obtained from the Boonton crusher plant, it will be noted that the ballast on cars from the Boonton plant cost practically 5 cts. per cu. yd. less than the material used on the Buffalo Division. The work on the Buffalo Division cost a total of 88.1 cts. per cu. yd, in track, which cost included the material, engine service, labor, tie renewals, and spacing, and interest on ballast car equipment.

Comments on Dump Wagons.

(Continued from p. 209, March 17, 1909.)

The Victor dump wagon is manufactured by the F. H. Hieber Wagon Manufacturing Co., of Pittsburg, Pa. The distinguishing device of the Victor is the ratchet and pall for dumping the load and winding the doors, which is on the side of the wagon. This device is operated by a single lever, and it is claimed that much time is saved by its quickness. The device is located just in front of the dump box and the chain controlling the doors runs under them. The winding and dumping device is very simple. Two pawls or dogs operate the ratchet wheel. One holds the load until it is released by the lever for dumping and the second one winds up the doors.

The wagon has a fifth wheel and transom plate in one piece. The hinges on the doors are well up on the sides of the body, thus allowing them to swing free of the load. A 1½ cu. yd. wagon weighs 2,025 lbs.

The Briggs Labor Saving Specialty Co., of Waterloo, Ia., manufacture a bottom dump wagon. The doors open across the box and slide up rods when passing over obstructions, which allows the doors to clear the load if it is so desired. The rear door, however, can be controlled by means of clamps, thus holding it to any desired height, and in this way it can be used to spread the load as it passes over it. It will spread material in layers measuring from 3 ins. up. The frame of the wagon is made of steel, and the dump box hangs from this frame. This makes a low wagon, a 2-cu. yd. wagon, being but 4 ft. 8 ins. high.

In addition to these bottom dump wagons there are a number of manufacturers who make dump boxes. These boxes are wagon bodies that are meant to fit on any running gear. These boxes are economical where dump wagons are not needed continually, as they can be stored away and the running gear used for other purposes.

The Koob dump box is manufacturer by the Koob Dumping Wagon Co., of Moline, Ill. This box is readily fitted to and intended to be used on any regular teaming or farming gear. The bottom has four doors instead of two, and these doors are not controlled by chains, but two bails of iron go under each set of doors, these bales holding the doors when closed and releasing them when the lever is thrown backwards. Each set of doors is operated independently, a lever for the purpose being on each side of the wagon. The doors can be opened part way or thrown entirely open. This arrangement allows of part of the load being dumped in one place and the rest in another, or the entire load can be spread out over a large area of ground. The doors being narrow, do not interfere with the load after it is dumped, as in the ordinary dump wagon. The doors can be closed by one motion of the lever, and they are said to be sand tight. The wagon is short coupled. Nearly all dump boxes can be coupled shorter than dump wagons, as the entire body of the box can be used to hold the load, while this is not the case with the bottom dump wagons.

The Koob box is made in three sizes, 1, 1½ and 3 cu. yds. The boxes are built of white oak and yellow pine, and are heavily ironed. The doors are of wood.

The Troy Wagon Works Co. also make a dump box. This box has four steel doors instead of two. It is built exactly like the Troy dump wagon with the same dump device and the tubular bar on the side of the wagon to wind up the doors. The top edges of the box are all covered with iron to prevent wear from shovels. The box is made to have a capacity of 1½ cu. yds.

The Everett Manufacturing Co., of Newark, N. J., manufactures the Everett portable dumping box. The device for holding the doors, four in number, in place is a heavy steel truss bar. The chains by which the bottom are operated are fastened to the steel tube running through the box at the front end, and then pass back alongside the box and down over the rollers to the ends of the steel truss bar, to which it is fastened by means of grab links. The entire load can be dumped at once or the load can be spread. To accomplish this it is only necessary to take up an equal number of links on either side of the box, by means of the grab links, thereby decreasing the opening between the doors, when dropped; then while the horses continue to walk, the load is distributed. Any slack in the chains can also be taken up with the grab links. The rod under the body and the chains on the sides act like a large band running around the body, helping to keep it in shape. Rollers on the bottom of the doors running against the truss bar allow of the doors closing easily.

The load is dumped and the bottom of the box is closed, by means of a foot lever, thus leaving the driver's hands free at all times to attend to his horses. The doors close tightly so they do not leak. They are made of wood, and each of the two inside doors has three hinges on it. The boxes are made in two sizes to fit any gear, namely $1\frac{1}{2}$ and 2 cu. yds. Larger sizes are made on special orders.

The Black Manufacturing Co., of Chicago, Ill., are the makers of the Chicago Quick Dumper. This box looks like the ordinary body to a wagon, the doors, two in number, being hinged in the center of the wagon. The box sits on the bolsters of the wagon and the entire body or box carries the load. Each door is divided into three pieces, so as not to interfere with the bolster of the running gear. The doors are opened and closed without the use of chains, rods being used for this purpose. The doors on each side are operated separately. The body also has a tail gate that can be let down like a farm wagon. The sides and ends of the box are straight up and down so that the capacity is large. Special boxes can be built to fit a long coupled wagon, but ordinarily the wagon is short coupled, even for 3 cu. yds. capacity. The fact that the doors are not continuous, but in three parts each, also allows of the wagons being short coupled. These boxes are made with capacities from 1 to 5 cu. yds.

The Ohio dump box is built by the Ohio Road Machinery Co., of Oberlin, O. The doors on this box are four in number, and are held shut by two truss bars under the box; each of the bars is operated by a single chain from the winding bar in front of the box. One chain is on each side of the box. Each truss bar controls one outside and one inside door and is connected at the chain. The end of each bar opposite the chain connected end is suspended by a long link from a truss hook placed on the outside of the box. The load is dumped and the doors wound up entirely by levers operated by the driver's foot, there being one lever to dump the load and another to wind up the doors. The boxes are made to fit any gear, the standard size being for a wagon with 38-in. bolsters, the box having a capacity of 2 cu. yds. However, the boxes are made of four sizes, $1\frac{1}{2}$, 2, $2\frac{1}{2}$ and 3 cu. yds. The weights of these boxes vary from 635 to 775 lbs.

The Atkins dump box is manufactured by the Henry M. Glen Wagon Co., of Seneca Falls, N. Y. This wagon body has four doors and their movements are controlled entirely by chains, which pass along each side of the box and through it. The dumping and winding device is the same as on the Star dump wagon built by this company. The workmanship on the box is also similar. The box is made to hold $1\frac{1}{2}$ cu. yds.

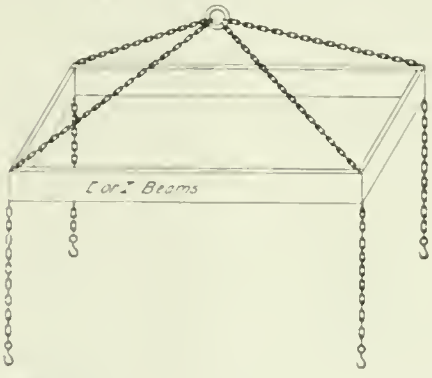
The Aurora dump bed is made by the Western Wheeled Scraper Co., of Aurora, Ill. This box is built in a manner similar to the Aurora dump wagon, and has the same device for operating the doors. The bed is furnished with a stub reach, the reach on the gears being removed before putting on the bed.

The Eagle Wagon Works, of Auburn, N. Y., make a dump box modeled somewhat after their dump wagon. It fits on a regular trucking gear and sits low. The doors lap and are supported at each end. They are made of hardwood and are ironed with wrought iron. A hand lever closes the doors, while they are dumped by a foot lever. The ordinary size made is $1\frac{1}{2}$ cu. yds. capacity. The doors can be arranged so they will spread the load as well as dump it in a single pile.

There is a much greater field of usefulness for dump boxes, in our opinion, than either manufacturers or contractors ordinarily suspect, as there is no reason why they should not be treated as skips and be handled by derricks, locomotive cranes, or cableways, and thus loaded and dumped.

Under the head of special wagons we have referred to the Newman wagon or car as used in Chicago. Any dump box with the proper dumping device and lever on it can be used in a similar manner.

The first dump box to be so used, to the best of our knowledge, was the Chicago Quick Dumper. On the new depot in Chicago, being built by the Chicago & Northwestern Ry., the Bates & Rogers Construction Co. being the contractors, the sand and gravel for concrete is hauled in these dump boxes. A large hopper is built over the mixing plant. The load is driven up to the hopper and a bridle attached to a derrick is hooked onto the box, which is raised over the hopper and dumped, after which it is returned to the gear. It is stated that only one minute is consumed in raising, dumping the box and returning it to the gear.



Sling for Handling Dump Wagon Bodies With Derricks, Etc.

One of the editors of this journal timed a Newman wagon in unloading onto a large stock pile and with three men to hook on the bridle a box was unloaded and returned to the wagon or car every $1\frac{1}{4}$ minutes. These boxes were of 3 cu. yds. capacity, as were the Chicago Quick Dumper boxes. The bridle used is shown by the accompanying sketch, and can be made at any shop. Four pieces of steel with eyes in them to receive the hooks on the bridle must be fastened to the dump box.

In excavating cellars and similar deep pits, these boxes could be used in connection with derricks to eliminate the steep, hard pull from the pit or cellar and save the use of a snatch team, or by having several extra boxes they could be lowered by the derrick and loaded ready to be placed on the wagon when it returned with an empty box from the dump. This would mean less delay to the wagon than when loaded by other means. In loading these boxes they could be placed near a roost and material caved directly into the box. Other material could be shoveled into the box easily, as the sides are low.

When traction engines were first used to haul wagons, the latter were simply those built for horses, and by changing the pole they were adapted to be coupled to the engine in trains. It was found that these wagons were quickly racked to pieces by the engines, hence the wagon manufacturers began the building of wagons for this special purpose. Some of these wagons are meant for heavy hauling of all kinds, while others are bottom dump wagons and will be described and commented upon here.

The Troy Wagon Works Co., of Troy, Ohio, has lately placed such a wagon on the market. This wagon or car is built in a manner similar to this company's dump wagon, with the tubular bar on the side of the wagon to control the doors, which are of steel. It is a reversible wagon, that is the two sets of wheels are of the same size, and the wagon will run in either direction equally well. This saves turning the whole train of wagons, allowing the wagons to be dumped while the engine is being turned and attached to the other end of the train. However, this wagon will turn in a small space. The capacity of the wagon is 3 cu. yds., the wheel base 6 ft. 10 ins., height 6 ft. $3\frac{1}{2}$ ins. and the total length 12 ft. 2 ins. By the pivot axle arrangement the load is carried directly and practically at the ends of the axle. The wheels have 4-in. tires.

For some years the Port Huron Engine & Thresher Co. have manufactured a car or wagon. The running gear is made of steel, the wheels having wrought iron spokes. The frame and body are made of maple, stayed with bar iron. The front hitch or tongue is made of steel angles and bars. The coupling includes a spring to reduce the shock of starting. The rear hitch is made of steel. A draught rod extends forward and is anchored in cross timbers in which the front bolster is anchored, to avoid strains to body and misplacing of axles.

The body is hopper shaped. The doors run across the wagon, and are worked by means of two handles. A small platform on the side of the wagon allows the man to operate the handles to dump and wind up the doors. The body is lined with steel. The doors are of steel. The material can be dumped outright or it can be spread at any desired thickness in uniform depth, $1\frac{1}{2}$ ft. wide. The front wheels are smaller than the rear wheels and turn under the body. The wagon has a capacity of

300 sq. yds. and on good roads will carry 5 tons.

The Acme Road Machinery Co. of Frankfort, N. Y., make a wagon or car especially designed for road construction, although it can be used for other purposes. The axles and wheels are of steel, the latter having an 8-in. tread. Both sets of wheels turn under the body, thus allowing the wagon to be run in either direction. The body is lined with steel. Four wheels control the doors, which open across the wagon. The doors can be so regulated that the wagon will spread its load in an even layer. The weight of the car is about 6,000 lbs., and it has a carrying capacity of 5 tons.

The Michigan Wagon & Mfg. Co., of St. Johns, Mich., make a wagon or car. It is called the Michigan spreading car. The wheels, with a 12-in. tire, are made of steel as are the axles. The frame of the wagon is likewise of steel, while the body, which is hopper shaped, is made of hardwood, lined with steel. The doors, four in number, open across the body, and are controlled by ratchets and pawls, operated by a man standing on a platform, on the side. The entire load can be dumped or it can be spread in uniform layers varying from 1 to 26 ins. deep. The wheels are of the same size and the car can be propelled in either direction, thus saving turning it, although it can be turned in a short space. The wagon is made in three sizes to carry 7, 10 and 15 tons.

Russell & Co., of Massillon, Ohio, manufacture a dump wagon or car. These wagons are all steel. The wheels all being the same size, run under the bodies of the wagon. The wagon can turn very short, but it is also reversible, running equally well in either direction. The tires are broad. The wheels track with those of the engine. These wagons are made to carry 5 tons or more.

The Buffalo Pitts Co., of Buffalo, N. Y., manufacture a dump wagon or stone spreading car. The axles and wheels are made of steel and are built to carry heavy loads. The tires are 10 ins. wide and ¾ in. thick. The body is hopper shaped and has four doors on it running across the wagon. The doors are controlled by chains and can be operated at will of the operator. The load can either be dumped or spread in a uniform layer of from 1 to 21 ins. deep. The car is constructed with a swivel truck at each end, thus admitting of its being moved in either direction without turning. The body is 14 ft. long and 5 ft. wide. It has a capacity of 10 tons.

All of the six above described makes of wagons or cars are meant to be used in trains and can be propelled by traction engines. We have already commented upon the use of dump wagons in trains in this series of articles.

The next style of dump wagons to be considered will be end-dump wagons.

(To be continued.)

Roads and Streets Section

Note: This Section is devoted to methods and costs of road and street construction. It will cover road building in all its details, the construction of pavements, sidewalks and gutters, the testing and use of paving materials and the machinery and tools used in road building and paving.

Economic Hints for Macadam Road Contractors.

IV.

(Continued from March 17 issue.)

59. Granite and trap rock do not ordinarily yield as large a percentage of fine screenings as limestone, nor is the screenings of a quality that causes the macadam to bind together as quickly. By adding some fine limestone screenings (as fine as can be secured), or by adding some loamy sand (if permitted under the specifications), the granite or trap macadam can be quickly bound.

60. Having rolled the stone dry until the screenings have mostly disappeared into the voids of the coarse stone, drench a short stretch (say 100 lin. ft.) of the macadam thoroughly with water from a sprinkler. Do not make the mistake of sprinkling the water over a larger area, but concentrate on a small area, for one of the objects of sprinkling is to wash the fine screenings down into the voids of the coarse broken stone. It takes a good volume of water to do this properly.

61. If water is abundant, and may be had with a short haul, use a large quantity of it, for it serves to compact the macadam by its puddling action and reduces the amount of rolling necessary. The writer has used as much as 18 cu. ft. of water, or 135 galls. per cu. yd. of macadam, which is equivalent to 22½ galls. per sq. yd. of 6-in. macadam. This amount should never be used unless the water can be had at very low cost.

62. Ordinarily 4 cu. ft., or 300 galls., of water per cubic yard of macadam is sufficient. This is equivalent to 5 galls. per sq. yd. of macadam 6 ins. thick. Yet it is not uncommon to see two or three times this amount used, depending on the foreman and upon the whim of the inspector.

63. On clay soil the minimum of water should be used to bind the macadam, for an excess of water softens the subgrade and results in the pushing of stone into the subgrade under the action of the roller.

64. Avoid laying macadam on a clay subgrade in rainy weather or immediately after a rain, for the reason just given. One contractor, known to the writer, had to add several inches of stone over the entire surface of a macadam road built in the late fall of the year, because of loss of stone in a clay subgrade softened by fall rains.

65. On the contrary, a sand subgrade should be drenched with water (if the cost of water is not prohibitive), for wet sand is not so easily displaced as dry sand. A 10-ton roller will drive the stone into dry sand, often to such an extent that the sand will come up through the voids of a layer of stone 4 ins. thick.

66. Among the various expedients to prevent the pushing of stone into a sand subgrade are the following: (a) Spread a thin layer of straw over the sand and roll it down before putting on the broken stone. (b) Spread a layer of ½ to 1½ ins. broken stone about an inch thick and roll, preferably using a steam roller weighing about 6 or 7 tons; but use the regular 10-ton roller if no other is available. (c) Cover the subgrade with thin cheese cloth, and on it place a thin layer of broken stone and roll. (d) Spread a layer of brush ¼ to ½ in. thick, roll and cover with a layer of gravel 1 in. thick, and roll again. This method has been used in preparing a yielding clay subgrade, and seems equally applicable to sand. (e) If clay or loam can be had with a short haul, spread a thin layer over the sand, wet with water and mix with a farm cultivator until the clay puddles the voids in the sand. Roll and allow it to dry before applying the layer of broken stone.

67. Do not excavate sand to the subgrade shown on the engineer's profile, unless some of the above methods of consolidating the subgrade are to be used, but excavate down to within about 2 ins. of subgrade. Spread the stone and roll; the stone will be driven down about 2 ins. and the sand will rise between the stones, filling the voids in the bottom 4 ins. of stone, thus making a satisfactory macadam base on which to lay a macadam wearing coat 2 or 3 ins. thick bound with screenings. This can only be done where engineers are reasonable enough to permit a deviation from ordinary forms of construction.

68. If macadam is laid in a trench between earth wings or shoulders, do not dig this trench the full specified width in sand or in soft earth, for the roller will cause the broken stone to shove the earth back laterally at each shoulder and there will thus be produced a width of macadam that is 6 to 12 ins. greater than specified.

69. Have the engineers set grade stakes or plugs every 50 ft. along the road, and on each side of the road, the stakes being driven exactly 1 ft. outside the line of the edges of the proposed macadam, the top of each stake being exactly level with the top surface of the proposed macadam at its center or crown. If the engineers refuse to give such stakes after the rough grading is finished, and before the trench for the macadam is dug, hire an engineer of your own to do so; for without such stakes

it is practically impossible to excavate the subgrade so there will be no depression in it. Such depression, even if slight, consumes a great amount of stone in the course of a mile. By stretching a string or wooden straight edge across the road from stake to stake, an accurate crown can be excavated between stakes. Then, by using three "targets" to sight along, the subgrade between the "stations" and "plus 50's" can be graded to its proper level. A "target" is conveniently made of a 1x2 in. piece of wood, 3 ft. long, with a strip 6 ins. long nailed across the top. Stand one "target" in the center of the road at one station after it has been graded to a true crown; stand the other "target" in a similar position at the next station that has been similarly graded. Have the third target held at intermediate points while a man sights along the tops of the other two targets; then any hollows or humps will be readily discovered.

70. If the foreman of the grading gang is provided with a Locke hand level and taught how to use it, there will be few errors in grading.

71. A 10-ton steam roller is usually specified for rolling macadam. Such a roller will consume 0.33 to 0.4 ton coal per 10-hour day. A safe estimate is 800 lbs. coal daily. It will consume 7 to 8 lbs. of water per lb. of coal. [A gallon of water weighs 8.33 lbs.] Hence it will require somewhat less than 800 gals. per 10-hour day.

72. See to it that the water tank on the roller is large enough to supply the roller with water for half a day's work. If necessary enlarge the tank to meet this requirement, for it does not pay to stop a roller to take on water at any other time than the noon hour and before the start of the day's work.

73. The tank and the roller is ordinarily filled very slowly when fed with a hose from the sprinkling wagon, because neither the hose nor the pipes are ordinarily large enough to permit rapid discharge of the water. Therefore, provide pipe and hose of 2 to 3 ins. diameter.

74. City ordinances often prohibit the use of soft coal, in which case coke or anthracite must be used; but in country work soft coal is generally used because of its cheapness. Do not unload the coal directly upon the ground, but provide a well made platform, for otherwise much of it is lost.

75. Require the roller engineman to keep a record of all coal delivered. Also require him to measure all coal in boxes or bags of known capacity before putting it in his coal tank on the roller. Thus a check is secured on the honesty of the coal merchant, as well as on the efficiency of the engineman in firing his boiler.

76. Do not employ a fireman in addition to the engineman on a roller. The increased output of rolling does not justify this additional expense.

77. See to it that the roller is run with the high speed gear except, of course, when first rolling the loose stone and when climbing hills. It is the number of times that the roller passes over the macadam that counts, yet enginemen are prone to use the slow speed, for it does not keep them so busy firing, etc. Nearly all steam rollers are equipped with two speed gearing.

78. The rolling of the stone should begin at the outer edge and be gradually carried toward the middle. If the reverse is done, the stone will be shoved out laterally to such an extent that the road will not "hold its crown," that is, it will flatten out.

79. Roll the coarse stone until it is so compact that it is not easily displaced by a broad tired wagon loaded with stone passing over it. Then apply the screenings, and not till then.

80. Attach an odometer to the roller so as to measure the number of miles traveled daily. This is the best check on the faithfulness of the engineman. It has a surprising effect, especially if the engineman is paid a bonus on the mileage covered.

81. Including the rolling of the subgrade, it is safe to count upon 210 sq. yds. of 6-in. macadam rolled per 10 hour day, or 40 cu. yds. of solid macadam. Any less than this is usually due either to inefficiency of the engineman or to failure to deliver sufficient stone to keep him busy.

(To be continued.)

Macadam Road Construction at Port Arthur, Ont., with Some Costs.

In 1907-8 the city of Port Arthur macadamized Cumberland street for a length of 4,100 ft. and a width of 46 ft. The total area paved was 20,956 sq. yds. In order that the macadam could be used at a later period as a foundation for a permanent pavement, the grade for part of the street was kept 6 ins. low, this of course necessitating considerable extra excavation. The macadam was treated with Tarvia and in all places where the right amount of screenings was used it has given excellent results. At the time the street was macadamized the street railway track was shifted from the center of the street to one side in order to allow for double tracking.

The surface was first ploughed and excavated so that the subgrade was 18 ins. below the finished grade. The subgrade was thoroughly rolled and all soft places and sewer trenches filled with broken stone. On this subgrade was laid a course of the largest size of crushed rock (2 in. to 3 in.), this course was rolled, and thus compacted to a 5-in. course. On this course were laid the ties for the street railway track, consisting of 3-in. planks. Sixty pound rails, 1½ ins. high were used; consequently the finished thickness of the pavement was 12½ ins. The tracks were placed 11 ft. centers, the distance between the outside ends of the ties thus being 13¾ ft.

A total of 10,160 cu. yds. of crushed rock was used for the macadamizing. This includes 800 cu. yds. used for filling trenches for tile drains, filling soft places, etc. On this basis but about 1.16 cu. yds. of loose stones and screenings were used per square yard of macadam. This was due to the fact that practically no rolling could be done on the track allowance, 19 ft. wide.

The cost of macadamizing the street was as follows:

Materials	Total	Per Sq. Yd.
Printing	$ 25.50	$ .001
Crushed rock, 10,160 cu. yds.	17,818.62	.850
Tarvia	2,334.20	.111
Lumber	50.71	.002
Hardware	32.20	.001
Coal for steam roller	135.45	.006
Sundries	9.42	.000
Labor		
Excavation, 7,375 cu. yds. at $.50	3,687.50	.176
Engineer and helper, steam roller	1,302.50	.062
Foreman	1,256.10	.059
Laborers	3,297.99	.160
Engineering	299.50	.014
Total	$29,950.05	$1.442

The labor cost of spreading rock, sprinkling, rolling and other miscellaneous items as well as handling and spreading the Tarvia was 28 cts. per sq. yd., or 57½ cts. per cu. yd. (loose) of stone handled.

The cost of rolling including labor and coal but not including oil, waste, repairs, etc., was 6.8 cts. per sq. yd., or 11 cts. per cu. yd. (loose). The actual labor cost of handling the rock and spreading Tarvia was about 31 cts. per cu. yd. (loose measurement). Each man handled about 6½ cu. yds. of stone per day.

The macadamizing was done by inexperienced laborers and foreman and under all sorts of difficulties in the shape of double-tracking the railway, excavating for the low grade, putting in sewer connections, etc. The wages paid per hour were as follows:

Laborers	$0.20
Foreman	.35
Teams	.50

Ten hours constituted a working day.

The work was done by day labor under the supervision of J. Antonisen, city engineer, and the above notes have been taken from Mr. Antonisen's report.

A bill has been introduced in the Pennsylvania Legislature providing for a state highway from Philadelphia to Pittsburg. The bill provides that the road be located under the direction of the Governor, Attorney General and Commissioner of Highways, and after being located be constructed, or existing highways improved, by the Commissioner of Highways. After construction the road would be maintained by the state. An appropriation of $5,000,000 is provided, of which $3,000,000 will be available in the next two fiscal years, and $1,000,000 each in the two following years.

A bill has been before the California Legislature providing for submitting to the citizens at the November, 1910 election a proposition to vote on an $18,000,000 bond issue for state road purposes.

Unclassified and General Articles

Note: This section is devoted to methods and cost articles on construction work not properly coming under any of the preceding classifications.

An Efficient Index System for City Engineers' Offices.*

BY WM. GAVIN TAYLOR,
M. Am. Soc. C. E.†

The indexing and filing of plans, field notes, office calculations and other records in a city engineer's office is an important feature of the routine work. An efficient indexing system is a valuable tool and time-saving device—one which can easily produce actual dividends in time and money saved far in excess of the actual cost. Happily the older method, of burdening the mind of one of the assistants with the records of the office and the relative or probable location of a plan, book or other item, is disappearing and with it the thought that the spending of money on indexing and filing equipment is to be avoided.

Success in a filing system is marked by the ease and rapidity with which desired data can be found, and this depends primarily upon two elements: First, the fundamental structure of the system used; second, the faithfulness with which the system is operated. The best possible system under careless use produces poor results, and a relatively poor system handled with faithfulness may give general satisfaction.

In 1901, while city engineer of Medford, Mass., the writer made a study of indexing problems with special reference to the needs of the engineering office of that city. All available published data were read, and numerous systems in operation in other cities were carefully investigated.

The indexing methods examined could in general be classed under two heads: First, those in which cards were located alphabetically under the guidance of some key word selected by the indexer; second, those in which the cards were arranged under the guidance of some color scheme.

None of the systems found in use in other offices seemed entirely satisfactory for the needs of the local office. And here it is well to emphasize the fact that indexing methods are not always interchangeable; that a certain system may admirably fit conditions in one city and be unsuitable for those of another; and that there is no one *best* system applicable to all cases and conditions.

A study of the indexing system devised by Melville Dewey, sometime state librarian of New York, and adopted in many public libraries for the classification of books, pamphlets, etc., according to subject matter, brought forth admiration. The principle upon which the system is based seems the most rational, direct and positive of any yet devised.

Fundamentally Dewey's decimal indexing system is directly opposed to those embodying a color scheme or the use of key words. It stands in a similar relation to these latter systems that an ordinary dictionary does to March's Thesaurus. In the use of the dictionary you can, if you have a word (the "key"), readily find its proper pronounciation, derivation and meaning, but the reverse process cannot be worked, that is, you cannot start with the meaning—the idea—and find the word. March's Thesaurus, however, is based on *ideas* and attempts to cover the field left open by the dictionary as above pointed out. A concrete illustration has value in emphasizing the advantages possessed by an index systematized by *ideas*. Suppose one has in mind the thought that in a certain part of India, Asiatic cholera is native and always present, and it is wished to describe such a condition by the use of a single word which is either unknown or forgotten. The word epidemic comes to mind but it fails to carry the precise meaning of the word sought for. The desired word is a condition of health—sickness; and with this as a starting-point the exact word—endemic—conveying the idea is readily found. The final result would have been the same if the word epidemic, disease or any other word approaching the idea had been looked up.

In the decimal system of indexing the subject matter is systematically grouped and numbered in a degree of detail sufficient for the purpose in hand. Certain parts of the index system may be much more elaborately sub-divided than other parts, the character and amount of subdivision depending, in the main, upon the particular case. For the best results the sub-division of ideas should be carried sufficiently to limit the collection of but a few cards under any one number. If under contained use more cards accumulate under any subdivision than is desirable its idea should be split into two or more specific classes, additional numbers given to the new divisions, numbers added to the cards in the original subdivision under enlargement and the cards rearranged. In like manner the index may be expanded indefinitely, the enlargement of sections and the development of new ones being as natural as the forming of new cells in a growing plant.

The reference cards are numerically arranged in the index and all cards are gathered in groups, each group covering a particular phase, and having a definite and predetermined relationship with all others.

The decimal system has very great flexibility and an infinite extensibility and is therefore exactly suited for either the very small or the very large index. It also avoids the ambiguity which frequently arises in the use of an alphabetical system, and which cannot be avoided except through elaborate cross-indexing.

With Dewey's invention as a basis a system was evolved to fit the particular needs of the Medford office and this system, with modifications, has been adopted for the filing system in the office of the city engineer at Waterbury, Conn. Care was taken to effect a logical arrangement in the "index guide" and to maintain simplicity and uniformity throughout. The index guide is a schedule of ideas, a standard by the use of which each index card is definitely numbered and definitely placed in the index. The personal equation of the indexer does not enter into the relative placing of the cards—all is prescribed by one standard—and the difficulties arising through the use of key words are thus avoided.

In common use the index guide was but infrequently referred to by the office assistants, as they soon gained through memory the sequence of numbers. Yet the index guide was sufficiently elaborate to permit a person not previously acquainted with the system readily to find a desired card having reference to a survey, level note, calculation or observation, plan, photograph or contract.

A primary division in the index was made by assembling the cards under cover of a tab guide card bearing the name of a street or some important controlling natural object as a water course—Massachusetts avenue and Mystic river, as examples. A secondary division was then made by establishing 12 subdivisions, each of which was given a whole number, as 1, 2, 3, 4, etc. These secondary divisions depend upon the needs of the office and may be as follows:

1. Highways.
2. Sewers.
3. Sewage Disposal.
4. Storm Drains.
5. Water Supply.
6. Gas.
7. Electricity.
8. Public Property.
9. Cemeteries.
10. Water Courses.
11. Bridges.
12. Railroads.

Other secondary divisions may, of course, be added at will. Each of these divisions is visibly marked upon cards by means of 1/12 tabs and the numbers plainly printed on the tabs. Tab 1 is at the extreme left of the 3x5-in. card and tab 12 at the extreme right. Tertiary divisions are then made, basing the divisions upon the class or character of the subject, the divisions being numbered at the right of the decimal point as follows:

.1 Surveys & Stakings.
.2 Levels & Grades.
.3 Calculations & Observations.
.4 Plans.
.5 Photographs.
.6 Contracts.

The tertiary divisions are subdivided to any desired extent by adding figures in the hundredths and thousandths place. In arranging the subdivisions of a system it should be borne in mind that uniformity throughout the system is the desideratum.

Specific cards frequently referred to may have their precise location marked by placing directly in front of them a colored tab card bearing the specific number, the colored tab card thus serving as a flag. A case that comes to mind is this. Cards referring to profiles were, as a class, in more frequent use than any other.

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*Paper read at the Annual Meeting of the Connecticut Society of Civil Engineers, Feb. 9, 1909.

†Waterbury, Conn.

The reference number for a profile was always .411 and so, directly in front of the profile reference cards was placed a blue 1/12 tab card numbered .411. Following down under any particular street the highway profile cards are flagged under 1.411, the sewer profile under 2.411, the storm sewer profile under 4.411, the gas main profile under 6.411 and so on. In the Medford index the profile cards are the only ones thus far that are flagged, but as the index grows, more may be added if desirable. At the present time this index consists of about 35,000 cards, placed in 40 drawers.

An elaboration of one of the secondary divisions will give an idea of the amount and character of subsequent subdivisions.

1. HIGHWAYS

1.1	Surveys and Stakings
.11	Street lines.
.12	Land divisions.
.13	Buildings.
.14	Development—Construction
.141	Grading.
.142	Pavements.
.143	Sidewalks
.143	Edgestones
.144	Cross-walks.
.145	Gutters.
.146	Trees and planting spaces
.15	Survey and traverse lines.
.16	Triangulation.
.17	
.18	City lines.
.19	Miscellaneous.
1.2	Levels and Grades. (Sub-divisions similar to above.)
1.3	Calculations and Observations: (Sub-divisions similar to above.)
1.4	Plans and Profiles:
.41	Street lines, acceptance plan.
.411	Official grade lines.
.42	Land divisions.
.421	Assessors' plans.
.43	Buildings.
.431	Restriction lines.
.432	Street numbering plans (with similar continuation)
1.5	Photographs:
1.6	Contracts:

The elaboration of the other secondary divisions, Sewers, Storm Drains, Railroads, etc., is made in a similar way, the detail figures being kept uniform throughout the whole system so far as practicable, e. g., the tertiary divisions should be absolutely constant and their further subdivision as nearly so as possible. In the index cited .1 is always a survey note, .3 is always a calculation, .4 always a plan, and further .411 is always a profile. By maintaining such a constant sequence in the figures the mastery of the system becomes easy and the efficiency enhanced.

To show the ease with which a reference card may be found, let it be assumed that the plan case location is desired of the profile of the 30-in. water main on Florence St. between Harvard Ave. and Lawn Terrace. Turning to the guide card marked Florence St. we have before us all the reference cards relating to Florence St. The subject sought is one classed under Water Supply, so we look for tab 5 cards, remembering that profiles are flagged by a colored guide tab marked .411. We touch this colored tab, tipping it toward us, and find immediately back of it the cards referring to water main profiles on said street. If the street is not very long but one card is numbered 411, and that is the particular one sought for (see Fig. 1).

As an example showing the operation of the system, let it be desired to assign a number and write a card having reference to the survey and level notes made in staking out the edgestone or curbing in front of No. 1642 Boston Ave. By reference to the index guide the number 1.143 is at once assigned to the survey notes and 1.243 to the level notes. On long and important streets, such as the one cited, it may be that quite a number of reference cards will accumulate, each bearing the same number, as 1.143 in the example. These cards of like numbers are arranged according to relative position on the street or numerically according to house numbers.

The accompanying illustration shows the arrangement of an individual card and the character and appearance of a series of cards with tabs and guide cards.

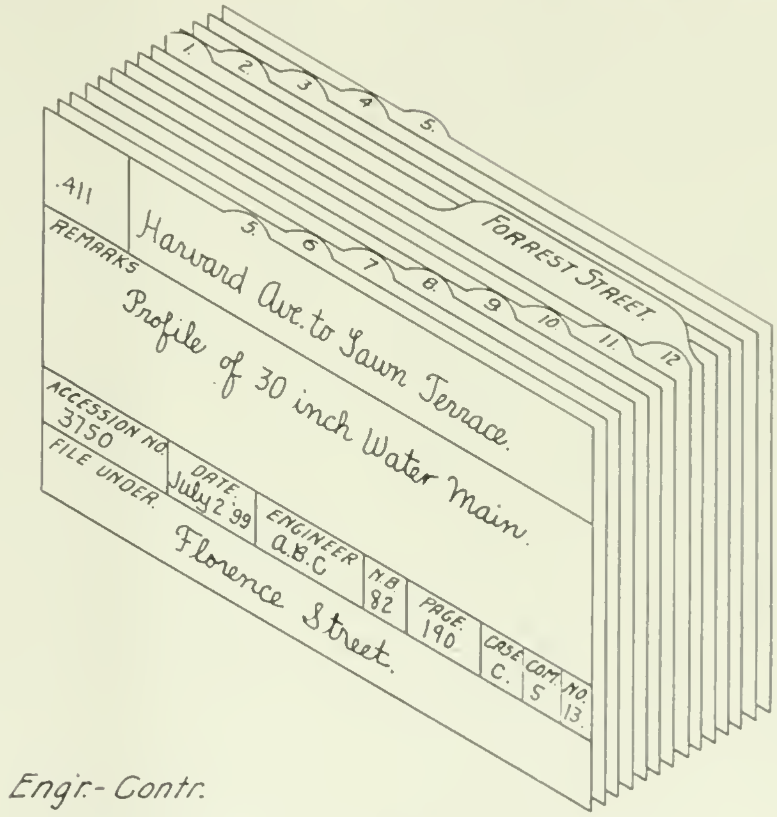


Fig. 1—Sketch Showing Arrangement of Cards in File.

In operation this system is simple, easily understood and conveniently operated, and is successful and efficient. One assistant should be given the general supervision of the indexing work in an office, be final referee for all disputed questions, and be held responsible for successful operation of the system in use.

Since arranging the system herein described (1901) the literature of the subject has been greatly extended and the decimal system has made a marked advance. Among the more important articles published in the technical periodicals, the following list of citations is given as an aid to those who may desire to read further on this subject.

Boston Elevated Railway Co. Description of method of filing plans, notes and other records. Paper read by H. C. Hartwell before Boston Society of Civil Engineers. Abstracted in "Engineering Record," [illegible] (1909).

New York Board of Water Supply. Detailed description of filing system adopted. A valuable and suggestive article by J. Leo Murphy. "Engineering News," [illegible] (1908).

Salt Lake City, Utah. Describes an elaborate system of filing engineering notes and records used by the City Engineer. "Engineering Record," [illegible] (1908).

Method of filing records in a City Surveyor's office described by Fred Gebelman. "Engineering News," July 2[illegible], 190[illegible].

Engineering index and library work. Description by G. W. Lee of system in use in the reference library of Stone & Webster. Also editorial. "Engineering News," June 16, 1904.

Hartford, Conn. Description by Frederick L. Ford of filing system of field notes and drawings in use in the City Surveyor's office. "Engineering Record," May 7, 18[illegible].

Filing system in engineering department of the Chicago & Eastern Illinois R. R. "Railroad Gazette," May 8, 1908.

Engineering Industries. An extension of the Dewey decimal system of classification. Bulletin No. 9, University of Illinois, November, 1906.

The same for application to Architecture and Building. Bulletin No. 13, University of Illinois, November, 1906.

The following figures taken from "Motor Traction" show the remarkable growth in the use of motor vehicles in London:

	Cabs		Omnibuses	
	Animal	Motor	Animal	Motor.
1903	11,404	1	3,623	13
1904	11,057	2	3,551	31
1905	10,931	19	3,484	241
1906	10,492	96	2,964	783
1907	9,818	723	2,557	1,205
1908	8,475	2,805	2,155	1,133

Method and Cost of Constructing Flexible Revetment for River Bank Protection.

The Department of Engineering of the State of California is now using a type of flexible revetment as a protection to river banks that is quite a departure from the kind previously employed by the department. The method that was formerly used was to make a mattress of brush fascines usually woven with wire or cable, and weighted down with loose rock laid on top of the mattress. If the slope of the bank below the water line, where it could not be graded, was steep, no rocks would lie on the mattress. Should erosion take place at the lower edge of the mattress, the latter would drop down, the rocks roll off and then the brush would rise with the water, be torn loose and carried away.

The type of revetment now constructed by the Department of Engineering developed from a plan originated by Nathaniel Ellery, state engineer, and was successfully used by him in bank protection work along the Eel river in Humboldt county, California. In the last annual report of the state engineer this type of flexible revetment is described and costs of its construction are given.

The plan consists of a mattress composed of brush fascines 8 to 12 ins. in diameter and about 20 ft. long, bound with wire. These fascines are laid double, breaking joints, and woven over and under with three galvanized wire "strands" or cables, ¼ in. in diameter. Galvanized anchor cables, ¾ to 1 in. in diameter, are laid on the slope extending from the barge floating in the stream to upon or over the levee to a safe point where a line of concrete blocks is sunk in the soil and connected by a ½ to ¾-in. diameter galvanized cable. These anchor cables are fastened to the line attaching together the line of "deadmen," or as called by the department, anchor blocks. The anchor cables are spaced about 8 ft. centers and are attached on the water end to a line of cable passing through heavy concrete blocks made on the barge. These concrete blocks are called by the department sinker weights. After this skeleton of cable and concrete work is set and ready, the mattress is woven on top of these cables and the mattress is tied or lashed to the anchor cables beneath the mattress every 6 ft. After the mattress is woven to its desired width another cable ¾ in. in diameter and galvanized, is drawn down over the mattress directly over the anchor cable. It is fastened to the anchor cable at 6 or 8-ft. intervals through the brush. The ends of this top cable are fastened to the anchor cable on the land end by a cable clip just above the brush mat and the water end is made long enough to reach the sinker block where it is fastened. Also, just at the water edge of the mat the anchor cable and the top cable are fastened together.

Above the water the mattress is woven in place on the ground which has been prepared by grading to a uniform slope. When the water's edge is reached the weaving takes place on the cables suspended over the water by placing planks on the cables. The barge is held off shore by spars or struts which are held taut by shore lines to the barge. After the mattress is completely woven, blocks of concrete 2 or 3 ft. square and from 6 to 12 ins. thick are placed on the mattress, the size and distribution of which depends upon the figured buoyancy of the brush and the force of the current to be resisted. These blocks are molded in place on the mattress and thoroughly fastened to the top cable usually with a turn or knot of the cable firmly embedded in the concrete. When the mat is thus made ready the barge is shoved away, permitting the structure to sink and conform to the bank slope. The mattress so made will, because of its flexibility, conform to the variations in the slope of the bank below the water where it could not be graded. Should the current cut under the edge of the mattress the weights will drop down, carrying the mattress down as the earth is washed away, and all—mattress and weighting—being secured by cables to the anchorage on shore, will continue to hang over the bank like a curtain. No weights can roll off and release the brush.

This type of revetment was used on Sherman Island in two places where the shore had been eroded by waves, and successfully protected the bank. The revetment on Sherman Island consisted of a mattress of willow brush in two sections, 176 ft. and 352 ft. in length, making a total length of 528 ft. The average width was 75 ft., and the average thickness 16 ins. The superficial area was 4,400 sq. yds. and the cubic contents 1,984 cu. yds. A total of 182 cu. yds. of concrete was used. The mattress was built from a barge, the upstream sections overlapping the previously laid section down stream. The work was done in 1908 by contract on the basis of cost plus 8 per cent. The cost of the work was as follows:

COST OF REVETMENT.

	Total.	Per cu. yd.	Per sq. yd.	Per lin. ft
Labor	$ 224.70	$0.113	$0.051	$0.422
Brush	1,489.70	.750	.338	2.865
Cable and clips	903.94	.455	.205	1.740
Equipment ...	96.10	.048	.022	.182
Concrete	1,313.35	.663	.301	2.535
Inspection	74.20	.037	.017	.142
Contr.'s com..	215.40	.109	.049	.421
Grand total.	$4,316.39	$2.175	$0.983	$8.317

In addition, grading costing $75, or $0.017 per sq. yd. of mattress, was done. This makes the total cost of the revetment $4,391.39, or $1.00 per sq. yd.

The item labor is for the mattress work and covers 715 hours of work, or 36 hours per cu. yd. of revetment, 0.16 hour per sq. yd. and 1.35 hours per lin. ft. Labor was paid $2.50 per day of eight hours. The item brush is for 1,983.99 cu. yds. of brush at 75 cts. per cu. yd. The item cable and clips is for 37,375 ft. of cable. The item equipment covers the following items:

Barge hire and watchman............	$170.00
Launch hire, 16 days....	65.00
Watchman, 17 days...................	37.50
Moving barge, checking gravel, etc....	13.85
Material, telephone calls, etc..........	10.97
Total	$297.32

This total was distributed over the revetment work proper and the concrete work. The barge hire and watchman for barge cost $10 per day and it cost $10 for tonnage to the barge. The item inspection covers surveys and inspection and was spread over the revetment work proper and the concrete.

The itemized cost of the concrete was as follows:

	Total.	Per cu. yd.
Labor, 995 hours............	$ 311.26	$1.729
Cement, $1.27 per bbl.......	305.64	1.695
Gravel, $1.25 per cu. yd....	218.00	1.211
Lumber and nails..........	84 07	.466
Equipment	201.22	1.118
Inspection	103.56	.575
Contractor's commission...	89.60	.498
Total	$1,313.35	$7.292

Another flexible brush mattress was placed on Brannans Island, the work being done by contract on the basis of cost plus 8 per cent.

The revetment consisted of a mattress of willow brush in three sections, 2,620 ft., 187 ft., and 175 ft., respectively; total length, 2,982 ft.; average width, 66⅓ ft.; average thickness, 14 ins.; superficial area, 21,892 sq. yds.; cubic contents, 8,586 cu. yds. This mattress was built from a barge, in sections 225 ft. in length, the upstream sections overlapping on the previously laid section downstream. The concrete used was 700 cu. yds. The unit cost of the work was as follows:

CONCRETE.

	Total Cost.	Cost per Cu. Yd.
Labor	$1,287.01	$1.830
Cement	1,161.29	1.659
Gravel	864.35	1.235
Lumber and nails...........	374.91	0.535
Equipment	1,198.25	1.711
Inspection	262.42	0.375
Commission	382.86	0.547
Total	$5,553.09	$7.901

REVETMENT.

	Total Cost.	Cost per Sq. Yd.
Grading	$ 229.59	$0.016
Labor	1,411.33	0.064
Brush	6,440.51	0.293
Cable and clips.............	5,727.24	0.262
Equipment	1,281.32	0.056
Concrete	5,531.09	0.252
Inspection	262.41	0.012
Commission	1,197.89	0.055
Total	$22,081.38	$1.004

At Merkeleys, a revetment was constructed to protect a river bank which had begun to cave badly. The work was done in 1908 by contract on the basis of cost plus 8 per cent. The revetment consisted of a mattress of willow brush in four sections, aggregating 774 ft. The average width was 40 ft. and the average thickness was 8 ins. The superficial area was 3,440 sq. yds. and the cubic contents 1,912 cu. yds. The concrete amounted to 145 cu. yds. The method of construction was the same as at Brannans Island, previously mentioned.

The unit costs of the work were as follows:

CONCRETE.

	Total.	Per cu. yd
Labor	$ 332.17	$2.296
Cement	289.58	1.997
Rock	243.61	1.681
Lumber, etc.................	213.75	1.474
Equipment	196 75	1.357
Inspection	46.75	.322
Contractor's commission....	101.00	.698
Total	$1,423.61	$9.825

REVETMENT

	Total	Per sq yd
Labor	$ [illegible]	$ [illegible]
Brush	1,4[illegible]	[illegible]
Cable and clips	1,0[illegible]	[illegible]
Equipment	[illegible]	[illegible]
Concrete	1,1[illegible].61	[illegible]
Inspection	[illegible]	0.146
Contractor's commission	[illegible]	[illegible]
Total	$[illegible]	$1.[illegible]

A similar revetment was also constructed in connection with the work of closing a break in a levee on the Kripp Farm in the city of Sacramento. The work of closing the break in the levee was done by day labor, the state engineer's department hiring a dredge and crew at $100 per day of 22 hours. The levee required to close the break was 1,600 ft long, 24 ft maximum height and 16 ft wide on top, containing 102,180 cu yds of earth. The actual cost of building the levee, including superintendence and inspection was $5,607.61, or 5½ cts per cu yd.

The revetment was built by contract on the basis of cost plus 10 per cent. It consisted of a mattress of willow brush, 710 ft long, 40 ft wide and 12 ins thick. The superficial area was 3,400 sq yds and the cubic content was 1,172 cu yds. The concrete used amounted to 100 cu yds. The mattress was made on the bank and in place. The unit costs of the work were as follows:

CONCRETE.

	Total Cost	Cost per Cu Yd
Labor	$247.06	$2.47
Cement	163.79	1.64
Gravel	135.00	1.35
Lumber	41.23	0.41
Equipment	138.28	1.39
Inspection	25.00	0.25
Commission	72.66	0.73
Total	$824.32	$8.24

REVETMENT

	Total Cost	Cost per Sq Yd
Labor	$ 174.18	$0.042
Brush	921.07	0.272
Cable and clips	548.92	0.162
Concrete	824.32	0.250
Inspection	148.00	0.044
Commission	184.48	0.054
Total	$2,773.95	$0.843

Important Features of the Annual Convention of the American Railway Engineering and Maintenance of Way Association.

Of the 18 committee reports presented during the three days of the annual convention held in Chicago on March 16, 17 and 18, those on roadway, on ballasting, on steel structures and on masonry contained information of general value to construction engineers and contractors. Of the remaining reports it should in fairness be said that their special nature alone limited their interest, each being more closely confined to matters concerning the railway engineer specifically than the reports named. The subjects reported upon were: Roadway, Ballasting, Ties, Rail, Track, Buildings, Wooden Bridges and Trestles, Masonry, Signs, Fences, Crossings and Cattle Guards, Signaling, Records, Rules, Water Service, Yards and Terminals, Wood Preservation, Steel Structures, Economics of Railway Location, Contract Forms and Electricity. We shall call attention here only to the distinguishing features of the four reports named in particular.

Roadway.—This report considered its subject under the divisions of track elevation, waterways, washouts, drainage and curing of slides, surface and subsurface drainage and tiling of wet cuts, and specifications. The matter of waterways is given a very comprehensive discussion by the late Walter A. Berg and for this alone engineers and contractors should secure and read the report. In addition the report contains a digest of practice in curing slides and washouts the main portions of which giving methods and costs will be published in a future issue of this journal.

Ballasting.—The great bulk of this report is devoted to methods and costs of producing ballast and of placing it in track. The Hog Mountain rock ballast crushing plant is described and full operating costs are given, this description is published as a separate article elsewhere in this issue. Methods and costs of washing and screening pit gravel for ballast and of mining cementing gravel based on actual records from gravel plants are given and they will be published in a future issue of this journal. There are some excellent data on burnt clay ballast and on the advantages and disadvantages of various types of ballast. In respect to methods and cost data this was the most valuable of all the committee reports.

Steel Structures.—This report contains a brief outline of the field work on impact tests which was carried on during the summer of 1908, and in the discussion which followed it was stated that the records were now practically ready for compilation. This investigation promises to be of high value in settling questions of railway bridge economics and we quote from Prof. Turneaure's remarks in discussion as follows:

"During the summer of 1907 some five weeks were spent in the field and in the summer of 1908 some nine weeks, parties were made up of from six to eight men, Mr. Crandall and myself being in the field continuously, the other members of the parties consisting of assistants, bridge engineers and other engineers on the roads on which experiments were being made. Some 40 bridges have been tested, spans being from 50 to 300 ft in length. On each of these structures runs were made with test trains using from two to four different types of locomotives and generally enough loaded cars to test the bridge fully. With these test trains about 1,600 separate runs were made. During the first summer we had eight extensometers in use and we obtained something like 1,200 records to tabulate, correlate and bring into final shape. The work has been done on eight different railways: the Nickel Plate, the Santa Fe, the Pennsylvania, the Norfolk & Western, the Northwestern, the St. Paul, the C. B. & Q. and the Rock Island.

"In working up this mass of material we have taken up first the deflection records, these being somewhat simpler to work up and less likely to individual and erratic variations. The deflection records have been pretty thoroughly worked up, and the committee will determine upon the publication of these records as to form. It has been impossible to meet and discuss these records as they should be before any conclusions can be drawn, but the records themselves will stand, and it was thought they will be of very great value to those who are particularly interested in this subject, so that the deflection records, it is expected, will be published soon as a separate bulletin. In general, from these deflection records we have found percentages of impact, so-called, or deflection over statical deflection, reaching all the way from 10 to 30 per cent over the longer spans and to [illegible] per cent over the shorter spans.

"One thing brought out by these tests which may be considered as definitely shown is that for all spans of considerable length, say 75 or 80 ft and over, the worst impact effect is produced when the train is going at such a speed that the rate of rotation of the drivers of the locomotive corresponds with the natural rate of vibration of the loaded structure, giving the cumulative effect due to these impulses from the excess balance of the locomotive drivers. That speed, which may be called the critical speed, is very well defined on the longer spans. On spans 200 or 300 ft in length, that critical speed will be 70 to 75 miles an hour. A lower speed will give very much less vibration; a higher speed will also give less vibration than this critical speed. For shorter spans, less than 75 or 80 ft in length, this critical speed is less than the ordinary maximum speed at which trains are run. These facts will appear in the published bulletin. The extensometer records involve a mass of data which have only been partially worked up, and the working up of the analysis and correlation will take considerable time. We expect to get all of this in form for final report next year, but it will take the greater part of the year to accomplish the work. It is quite likely that we should, in order to round up the work, make experiments on a few more bridges, probably some spans longer than those already tested. The longest span yet experimented upon is 300 ft. It will be of very material assistance to get a few points beyond that length, 400 and 500 ft spans if possible."

The report also gives directions for the maintenance of steel structures including their protection from corrosion and these will be published in a future issue of this journal.

Masonry.—This report relates wholly to concrete work and takes up arches and large abutment construction, retaining walls, reinforced concrete trestles, and specifications for plain and reinforced concrete. The report contains a large amount of valuable information which will be abstracted in future issues of this journal.

Banquet and Excursions.—Among the recreation features of the convention mention should be made of the banquet on March 17 at which notable addresses were made by the Hon. George W. Ross, ex-prime minister of Ontario; Mr. Blewett Lee, general attorney, Illinois Central R. R.; Dr. J. A. Holmes, chief of the technological branch of the U. S. Geological Survey, and others. On March 19 an excursion was taken to visit the plants of the Universal Portland Cement Co., at Buffington, Ind., and the great new steel works of the Indiana Steel Co. at Gary, Ind. This excursion was tendered to the association by the Universal Portland Cement Co. and the Indiana Steel Co., subsidiary companies of the United States Steel Corporation. Luncheon was furnished and every convenience given for a thoroughly instructive and enjoyable trip.

Election of Officers.—The following officers were elected to serve the association during the coming year:

President, William McNab, principal assistant engineer Grand Trunk.

First vice-president, L. C. Fritch, consulting engineer, Illinois Central.

Second vice-president, W. C. Cushing, chief engineer maintenance of way, Pennsylvania lines, Southwest System.

Secretary, E. H. Fritch.

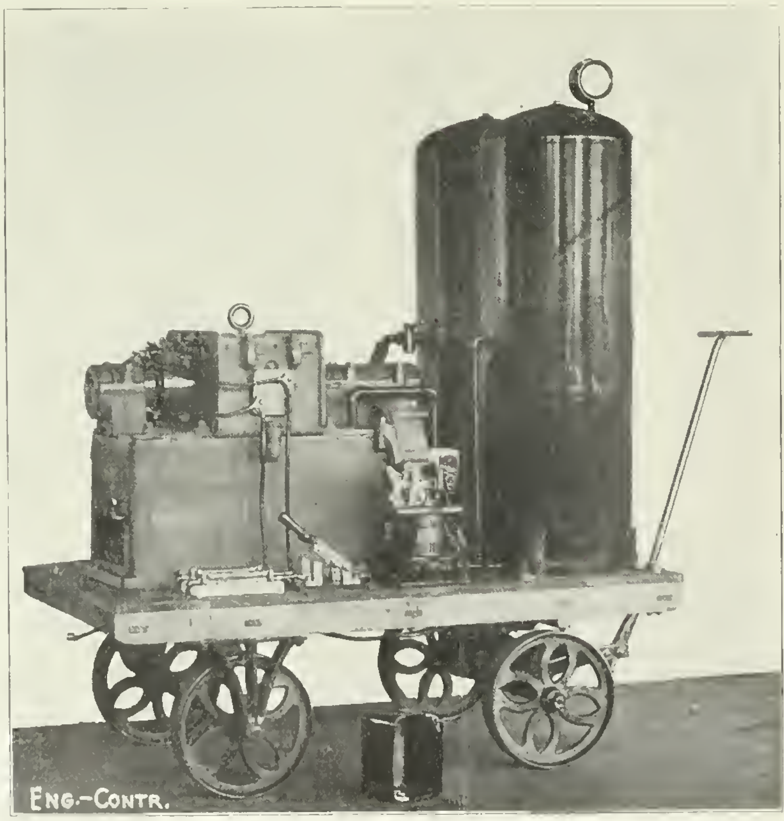
Treasurer, W. S. Dawley, chief engineer, Missouri & North Arkansas.

Members of board of directors, three years each, A. H. Rudd, signal engineer Pennsylvania railroad, and A. W. Thompson, chief engineer maintenance of way, Baltimore & Ohio.

Exhibition of Track Supplies.—The convention was made unusually interesting by the large and excellent exhibition of supplies and tools made by the Road and Track Supply Association. The exhibition occupied some 38,655 sq. ft. of the Coliseum and was made by 140 different firms.

An Electrically Operated Portable Air Compressor Plant for Contractors.

In trenching in rock and in frequent other jobs of rock excavation in cities, hand drilling is employed because of the trouble and expense of long pipe lines or frequent shiftings of compressors and boilers. In the accompanying illustration we show a portable compressor plant which would seem to solve to a large extent the problem of cheap and economical power for drilling operations where frequent moves are necessary. This compressor plant is one recently put on the market by the Allis-Chalmers Co., Milwaukee, Wis. It is electrically operated and is fitted with either alternating or direct current motors, as may be desired. The machine illustrated shows the direct current equipment; it is known as the company's D-4 portable compressor.



This compressor can be arranged for a capacity of 50 cu. ft. of free air per minute at 60 lbs. per sq. in. pressure, which is about what is required for a 2-in. drill of reliable make. This size of drill is about the largest that can be handled by one man and since the compressor outfit needs practically no attention on account of the automatic governer or un-loading device, if alternating current is used one man can run the whole outfit. If a steam driven compressor is used an extra man is required to attend to the boiler and compressor and the weight of the outfit makes it impossible to use for water pipe and sewer work.

Regarding the capacity and operation of the plant, the makers write us as follows: "With our D-4 portable air compressor outfit, using a 2-in. drill, one man could drill in ordinary hard rock 70 ft. of hole in 10 hours, size of hole ⅝ in. to 1¼ in. diameter. This includes time lost in setting drill and changing bits, which would be necessary in extra hard rock. The pressure may be run up momentarily to 90 or 100 lbs., but the compressor would not operate continuously at this high pressure on account of overheating. We can supply these outfits to operate on either direct current or alternating current. The direct current motors can be wound for 110, 220 or 550 volts. The alternating current motors for 110, 220, 440 or 550 volts, either 25 or 60 cycle, 1, 2 or 3 phase. If transformers should be required we can furnish them for stepping down to any voltage desired if a low voltage circuit is not available. The power company could probably best furnish these transformers if they are required as they should be mounted on the line poles on account of danger of bringing high voltage line to the compressor."

Catalogs Worth Having.

Engineers and contractors should have on file the latest catalogs of machines, tools and supplies that they use. In sending for catalogs reviewed or advertised in this paper, you will confer a favor on us if you will write direct to the advertisers and state that you saw the catalog mentioned in ENGINEERING-CONTRACTING. If you are in the market for tools, machinery or supplies, tell us and we will notify promptly the leading manufacturers.

No. 1152. **Belt Conveyors.**—The Conveyor Weigher Co., 90 West St., New York.

This company manufactures belt conveyors, but instead of the ordinary bearings of the rollers, a ball bearing is furnished. The claim is that less power is needed to operate the belt.

No. 1153. **Spiral Riveted Pipe.**—Abendroth & Root Mfg. Co., New York, N. Y.

A catalog of 127 pages, known as "Handbook 39," containing valuable hydraulic data. Also contains price list on spiral riveted pipe, hydraulic giants, pipe joints and connections and water tank boilers.

No. 1154. **Cropp Concrete Mixer.**—Cropp Concrete Machinery Co., 304 Oxford Building, 84 LaSalle St., Chicago, Ill.

An 8-page circular describing this non-tilting batch mixer, for which great simplicity and a very low charging arrangement are claimed. The charging arrangement is described as follows: "By our latest improvement we are able to load the drum at its base instead of above its center, and it is obvious that by this method, which is performed by very simple construction, more than one-half of the diameter of the drum is saved and the problem of low charging device has been solved. The material is loaded at the end and drawn in by revolutions of the drum by arrangement of blades. We also use high discharging device, loading directly into wheelbarrows."

No. 1155. **Road Oils.**—Standard Oil Co., Road Oil Dept., 26 Broadway, New York.

A 40-page catalog, handsomely printed, telling of the use of asphaltic oils for roads. The method of constructing "roller tamped oil roads" is described and illustrated. The illustrations in this pamphlet are exceptionally good.

No. 1156. **Railway Signals.**—The Hall Signal Co., New York.

This pamphlet is known as Circular No. 14, and is a description of the installation of upper quadrant, three-position semaphore signal on the Boston & Albany R. R.

No. 1157. **Plows.**—Parlin & Orendorff Co., Canton, Ill.

Circular telling of the P. & O. road plows and also heavy grading plows for railroad construction.

No. 1158. **Toggle Bolts.**—Star Expansion Bolt Co., Bayonne, N. J.

A price list of the various sizes of toggle bolts manufactured by this company.

No. 1159. **Hydraulic Gravel Elevators.**—Joshua Hendy Iron Works, 75 Tremont st., San Francisco, Cal.

A 31-page catalog telling of the elevators and water lifters manufactured by this company for use in connection with hydraulic mining and the sluicing of earth. A very useful catalog.

No. 1160. **Hydraulic Giants.**—Joshua Hendy Iron Works, 75 Tremont st., San Francisco, Cal.

A 15-page catalog illustrating and describing the various styles and sizes of monitors made by this company for excavating earth and gravel.

No. 1161. **American Ingot Iron.** — The American Rolling Mill Co., Middletown, O.

A series of pamphlets describing the non-corrosive ingot iron manufactured by this company. This iron is claimed to be 99.94 per cent pure. It is particularly suited to constructing metal culverts, roofing, piping and spouting which has to resist corrosion. The pamphlet relating to culvert construction should be secured by highway and railway engineers.

No. 1162. **Rail Testing Machine.**—Pennsylvania Steel Co., Steelton, Pa.

A folder describing the machine built by this company for testing the wear on rails and joints by wheels under all conditions of service, such as slipping drivers and braking.

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Some Careless Statements of the Value of Railways.

In an address on the "Costs of Railroad Transportation" recently delivered before the Terre Haute Science Club by Prof. I. C. Wagner of the Rose Polytechnic Institute we find the following statement:

> Two attempts have been made to secure an accurate valuation of railroad properties within a state. The first was made by Michigan in 1900 and the second in 1903 by Missouri.

As a matter of fact five states have up to the present time made valuations of railway property, namely, the two mentioned by Professor Wagner for purposes of taxation, one, the state of Texas, for limiting bond issues, and two for rate making, Washington and Minnesota, respectively. It would seem that Professor Wagner had neglected to post himself as thoroughly as he might on what has been done in the way of state valuation of railway properties. This is unfortunate because elsewhere in his address he says:

> Taking the average of the present values per mile (that is, those estimated for Michigan and Wisconsin—Editors) we have the best obtainable value per mile of railroads in this country, $23,500. This includes everything used in the transportation business and is the actual investment. While it is true that the costs per mile probably differ in the different states, yet it seems probable that the average of two states situated as are Michigan and Wisconsin will not differ greatly from the average for the entire country.

Apparently Professor Wagner overlooked the fact that the valuations in Michigan and Wisconsin were for purposes of taxation and that the figures are naturally low. Irrespective of this, however, it should be evident to anyone familiar with railway construction or with the value of railway terminals and other properties that $23,500 per mile is much below the average value for the entire country. Minnesota is not a mountainous state, yet the valuation per mile placed on its railways in the report recently made is $50,000. This amount may be nearer an average value, but an engineer is very bold who will set an average value per mile on railway property on the findings for one or two or five states. We noted last week some pertinent comments of the Interstate Commerce Commission on this identical point. Off-hand conclusions as to the value of railway property are seldom worth while and they are particularly useless when based on a part only of the scant available data.

Announcement of the First Meeting of the American Society of Engineering Contractors.

The first meeting of the American Society of Engineering Contractors will take place April 14 and 15, in the United Engineering Building, New York City.

A constitution and by-laws will be adopted and nominations of officers for the ensuing year will be made.

Mr. H. P. Gillette has received so many applications for membership in the society, that it is assured of starting with a much larger membership than was originally anticipated and a charter membership many times greater than the charter membership of any of the four national engineering societies.

A more detailed announcement of the coming meeting will appear in our April 7 issue.

Does a Lumber Crop Worth Only $3 an Acre Furnish Sufficient Argument for Forest Preservation?

That wholesale forest preservation is an economic blunder is not at present a popular contention, for "conservation of natural resources" has such a ring of common sense about it that to be in any way opposed to "conservation" is considered almost to be unpatriotic. Nevertheless, there is a vast amount of buncombe parading under the conservation banner. We have already gone on record against the wholesale preservation of forests, because we believe that reinforced concrete is an economic substitute for most of the timber now used.

We are informed by government statisticians that the country is annually harvesting 40 cu. ft., or 480 ft. B. M., of lumber per acre of timber land, while the annual growth of new timber is only 12 cu. ft., or 144 ft. B. M., and that, at this rate, our forests will last only 20 to 30 years. These data are intended to frighten the public into support of the Bureau of Forestry in its effort to control all the timber lands. But a little study shows that these very figures prove the fallacy of the contention that a lumber harvest is a profitable harvest when tree raising is conducted as a commercial proposition.

Less than 150 ft. B. M. can be harvested annually from an acre of forest land without cutting down more timber than is supplied by normal growth. If the saw mill is located at or near the forest, pine timber can be bought at the mill for about $20 per 1,000 ft. B. M. Hence, an acre of timber land will yield an annual harvest worth about $3 after it has been sawed into lumber.

Is it any wonder, then, that the Washington or Oregon land owner prefers to harvest all the crop that has been centuries reaching its present proportions? He would be a fool to let it stand and merely cut off the 150 ft. B. M. per year per acre, as advocated by the Bureau of Forestry, for there is none of this land that will not yield a crop of grain or fruit worth several times $3 per acre annually.

It is true that deforested land often lies many years unused, because it may be of a character that is less productive than other farm land. But, as the country settles up, the demand for land increases until it becomes profitable to cultivate lands that now are classed as second or third rate. Certainly no farm land, however poor, yields a crop worth only $3 an acre.

When the advocates of wholesale forest

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preservation find it difficult to convince the public that there is any appreciable profit to be obtained by raising crops of timber, they will rely largely upon their argument that forests are indispensable in preventing floods. The sooner they are forced to rely upon that argument the better, for then some reliable facts will have to be produced to prove the contention. As yet the contention rests upon a theory that is not accepted as tenable by many who have studied the subject.

The Defeat of the Washington Law Licensing Engineers.

We publish in another column of this issue a letter announcing the defeat of the act recently introduced into the Washington state legislature providing for the licensing of engineers. We also give the text of the act itself. It will, we believe, interest many of our readers to note the reasons given for the defeat of the Washington act. In brief it was unsupported by all but a few men of the profession.

There is doubtless a growing disposition to seek legislation regulating the practice of engineering. Four different states have to our knowledge attempted such legislation this winter. Three of these proposed acts have been published in these columns. We have made this publication because a great many engineers honestly believe that this kind of legislation should be enacted and because practically every engineer is interested in the questions involved. These questions are:

(1) Do reputable engineers need legislative protection from the competition of the incompetents and rascals within the profession?

(2) Does the public need legislative protection from the inefficient and defective works of rascally and incompetent practitioners of engineering?

The putting of these questions involves the premise that rascally and incompetent practitioners of engineering exist. They do exist, of course, just as they exist in every other profession or avocation that men follow for a livelihood. Granting the premise then, how is the first question answered? A considerable body of engineers says: Yes, we need this protection. Another body quite as large in number, perhaps even more numerous, says: No, or shows absolute indifference. The legislator says: What is there so different about the rascals and incompetents in engineering that the present criminal and civil laws that are depended upon to curb and punish such persons in other avocations do not apply to them also? Taking now the second question; what is the answer? It is, undoubtedly: Yes, the public welfare should be protected. Shall we do it by attempting to legislate rascals and incompetents out of the profession, or, shall we do it by establishing by law a board of review or of supervision of all engineers' plans for public works?

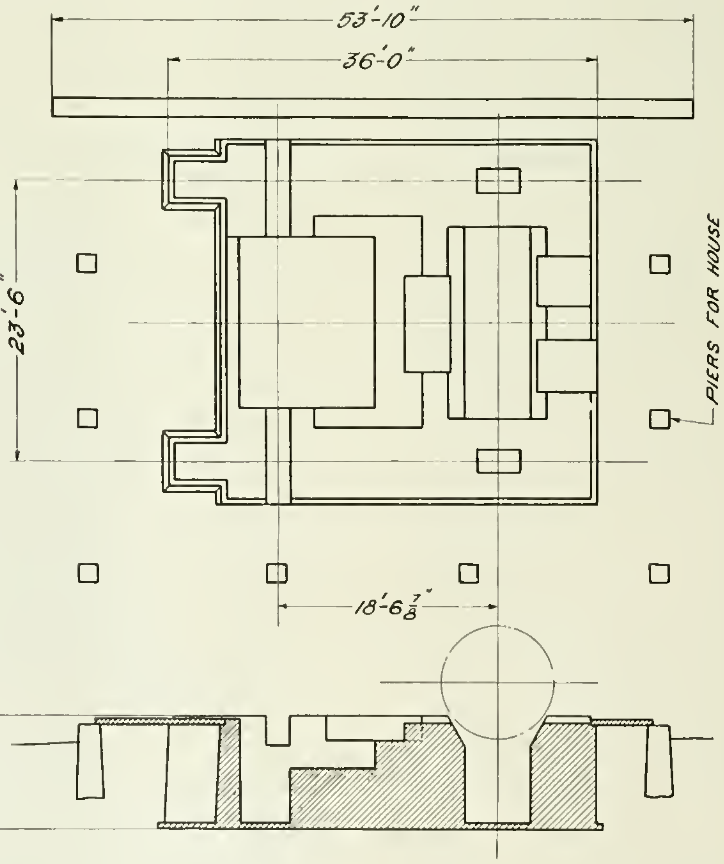
Concrete and Reinforced Concrete Section

Note:—This section is devoted to methods and cost of constructing concrete and reinforced concrete structures. It will cover the selection, testing and proportioning of concrete materials; laboratory tests of concrete; concrete mixing, transportation and placing; fabrication and placing of reinforcement, and form construction and erection. It will also contain articles on new and interesting developments in the design of reinforced concrete.

The Cost of a Large Engine Foundation of Concrete.

This foundation was built during the month of July, 1908, the weather being very good, except the last day when it rained heavily all day, and oil skins were furnished to the gang, in order to finish the work that day. Sand, cement and lumber were delivered on cars near the site, and were then hauled 600 ft. to place. The stone was clean, sharp, field stone hauled from a neighboring farm. The mixture used was 1-3½-6, cement costing $1.70 per bbl., sand 50 cts. per ton delivered on cars near the site. Laborers were paid $1.50 per day of 10 hours, labor foreman $2.50, and carpenters $2.25.

The foundation was rather complicated, as is shown by the drawing having over 60 bolts, set solid, the upper ends being encased by 4-in. boiler tubes to allow for possible inaccuracy of spacing holes in the engine bed. The cost of cutting tubes and setting bolts is included in the cost of concrete, of which there were 350 cu. yds.



Concrete Foundation for an Engine.

The cost per cubic yard was as follows:

Cement	$1.54
Sand and gravel	0.52
Stone	0.24
Oil skins	0.03
Lumber	0.11
Nails	0.01
Total	$2.45
Unloading and hauling cement	$0.02
Unloading and hauling sand and gravel	0.14
Building runs	0.02
Building forms	0.30
Removing forms	0.08
Cutting tubes	0.03
Setting tubes and bolts	0.07
Mixing and placing concrete	0.92
Tools, horse feed and fixed charges	0.10
Total	$1.68
Grand total	$4.13

We are indebted for this information to C. W. Laing, construction engineer, Dominion Coal Co., Ltd., Glace Bay, Nova Scotia.

Hints for Inspectors of Concrete Work.

I

Careful inspection is a vital factor in securing safe and enduring concrete work. No matter how well the engineer may design, his work will come to naught unless his design is accurately carried out by careful and skillful workmanship with good materials. The construction must be good and assurance of good construction is had in conscientious and competent inspection alone. The duties of concrete inspection are various and numerous. No practicable code of rules can cover them all in detail. The rules or directions that follow and will continue for several issues pretend to cover only some of the more important duties of the concrete inspector. We believe that they will be an aid to the young inspector beginning work and of the old experienced concrete inspector we would ask such suggestions for new additional rules and such modifications and changes in the rules given as his experience has taught him to be necessary and wise.

Proportioning.

American engineers proportion concrete mixtures by measure, thus a 1-2-4 concrete is one composed of 1 volume of cement, 2 volumes of sand, and 4 volumes of aggregate. The duty of the inspector is to make certain that the specified proportions are accurately and uniformly adhered to. This is simply a task of accurate measuring—it requires (1) that definite measuring units be employed, (2) that the accuracy of the measuring boxes, hoppers, etc., be verified; (3) that the filling of the measuring boxes, hoppers, etc., be exact, and (4) that, when two or more box or hopperfuls, etc., go to make up a batch, the exact number is employed for each and every batch. The inspector should bear in mind that while splitting hairs is not warranted by the exactness of the process of concrete making as it is conducted in practical construction work, slipshod and careless methods and practices should not be tolerated.

Method of Measuring.—When the method of measuring is not stipulated in the specifications, it is tacitly understood that it shall correspond to accepted practice in respect to accuracy, etc. Beyond this qualification the contractor's choice is unrestricted. The inspector shall see that a method is adopted whose accuracy can be readily verified and which is sufficiently simple for the ordinary workman to carry out without likelihood of frequent error.

Standard Units of Measure.—Determine the units of measure at the beginning. If they are not stated in the specifications see that a definite understanding is reached by both engineer and contractor of what they shall be. Cement is different in volume when measured loose and when packed in the barrel, cement barrels vary in volume of contents. It should be definitely understood by engineer, contractor and inspector (1) Whether the volume of cement used is to be the volume measured loose or the volume as packed in the barrel, (2) what the cubic contents of a barrel of cement or a bag of cement, shall be called. If the stone is measured in empty cement barrels have it understood whether a barrelful is the volume measured with the heads knocked out or the volume contained between heads, there is [illegible] cu. ft. difference. If the sand and stone are measured in wheelbarrows have it definitely understood what the volume of a wheelbarrow load shall be called; there is a cubic foot difference between the capacity of a wheelbarrow, water measure, and the load usually carried by men in wheeling.

Verification of Measures.—The measures used should be verified to make sure that each holds the amount intended. This can be very simply done by using a known measure to fill the measuring box, etc., employed, or the volume of the box, etc., can be computed mathematically.

Accurate Measuring.—See that the filling of the measures is reasonably exact, and, when several measures of each material are required to make up a batch, that the exact number is adhered to. When the men are being rushed or have grown careless through lack of watching, they are very likely to partly fill or to overfill the measures; this is especially liable when filling buckets, hoppers or cars to mark by means of chutes from overhead bins, also when the measuring is being done by wheelbarrow loads. Skipping a measureful when several measurefuls are required to make up a batch is another common error. Lack of system is chiefly responsible for this error. The operations of measuring should follow a regular routine or sequence which should not be varied from and a double check system should be used by which both the cement man and the mixer operator check the number of measures. While skipping a measureful of sand or aggregate entails no dangerous consequences (a batch of extra rich concrete results simply) the skipping of a measureful of cement results in a weak spot in the work. In reinforced concrete building work it results in a weak girder or column and is dangerous. No chances which vigilance and caution can avoid should be taken in measuring and charging the cement content of concrete for reinforced concrete work. Only a man of intelligence should measure and feed the cement and he should be made to understand that safety to life and property depends on the accuracy of his work.

Automatic Measuring Devices.—When automatic measuring devices are used to proportion the concrete see (1) that they are regulated to give the proper proportions, (2) that the materials do not clog, choke or arch in the feed hoppers, (3) that the feed hoppers are kept amply supplied with materials.

Sizes of Batches.—See that the batches [illegible] If the batch calls for parts of bags or barrels of cement or parts of barrows of sand or stone the proper [illegible] work.

Mixing.

Concrete is mixed by (1) hand turning with shovels and hoes, (2) by concrete mixing machines. Mixing by hand usually is employed only where the amount of concrete to be mixed is small or where frequent moves of the place of mixing are necessitated as in sidewalk work. The increasing portability of mixing machines is doing away rapidly with the last named reason for hand work. Except for [illegible] small jobs the use of mixing machines is in general practice.

Methods of Hand Mixing.—One of the following two general methods is usually employed in mixing concrete by hand: (1) The materials are spread in layers one on top of the other and turned dry with shovels; after being dry mixed water is added to the mixture and the mass is again turned with shovels. (2) The cement and sand are mixed into a wet mortar, to which the stone is added, and the whole mass is incorporated by turning with shovels. The number of turnings, the order of the various operations and other details of both methods vary with the practice of the individual engineer.

Specifications for Hand Mixing.—See that the specifications are clear as to the method of doing hand mixing and as to the perfection of the results required. Specifications are most likely to be ambiguous concerning the number of turns required and as to what constitutes a turn. The inspector should make his mind clear on these points and should see that the understanding between engineer and contractor is definite. In case the specifications do not stipulate the methods of mixing, etc., see that it is definitely understood by engineer, contractor and inspector what methods and results will be accepted as satisfactory.

Mixing Boards.—See that a suitable platform is provided on which to do the mixing and that it is kept clean from adhering material and from foreign matter. See that the planking is tight enough to prevent material leakage of water carrying cement. See that the platform is large enough to admit of efficient and rapid mixing.

Measuring Materials for Hand Mixing.—See that the rules for measuring given in the preceding section are adhered to.

Size of Batch in Hand Mixing.—See that the quantity of concrete in each batch is no greater than the quantity that, under the conditions, can be mixed and deposited in permanent position in the work before the cement begins to set.

System in Hand Mixing Operations.—See that the mixing operations are conducted according to a regular system. This permits the inspector to check the work and tends to produce uniformity of product that decreases the necessity of constant inspection for and correction of faults in the mixture.

Hand Mixing for Reinforced Concrete.—See that hand mixing for reinforced concrete work is done deliberately and carefully. Hand mixing should be avoided for reinforced concrete work if possible, but if allowed in an emergency, the inspection should be rigid. Hand mixing as done for ordinary mass concrete work will not do for reinforced concrete work.

Concrete Mixing Machinery.—Concrete mixers are of two types: (1) batch mixers in which the materials are charged, mixed and discharged in batch units, (2) continuous mixers in which the materials are charged, mixed and discharged in a continuous stream. A third division is sometimes made into gravity mixers; some gravity mixers are batch mixers and some are continuous mixers. General practice favors batch mixers for reinforced concrete work and whenever a specially uniform, well mixed concrete is required. Continuous mixers are considered satisfactory for mass concrete work, foundations, etc.

Type of Mixer.—See that the mixer used is of an approved type and that it is erected and operated in such a manner that the charging, mixing, discharging and regulation of the materials is uniform, efficient and certain.

Charging Batch Mixers.—See that the batch is composed of the proper proportions and that it is so charged into the mixer that the principle of batch unit mixing is fulfilled. This means that all the batch must be in the mixer and held there as a unit throughout at least the minimum number of turns or other operations necessary to produce a mixture of the required perfection.

Charging Continuous Mixers.—See that the materials are fed evenly into the mixer in the proper proportions. If the mixer has automatic measuring attachment see that the various feed hoppers are kept amply full and that the material does not "bridge" or "choke" and so cease to feed into the mixer drum. If the mixer is fed by shoveling see that the shoveling is done from properly proportioned piles of cement, sand and aggregate, that each shovelful contains a proper mixture of materials, and that the shoveling is done at a uniform rate. Even feeding is essential to good results from a continuous mixer and the inspector should watch this operation carefully.

Number of Turns.—See that the mixer is given the requisite number of turns for each batch. A certain number of turns is required to produce a concrete of any standard perfection of mix, if less than this number of turns is given to the batch an inferior concrete results. The requisite number of turns can readily be determined by trial mixing of a few batches and when once determined that number should be set as the minimum allowable.

Discharging With a Drop.—See that the concrete, in discharging the mixer, does not drop or fall for any considerable distance. Such a free fall has a tendency to segregate the stone from the mortar.

Cleaning the Mixer.—See that the mixer is cleaned of all adhering mortar or concrete when work is discontinued at night or for other reasons. A mixer caked with cement operates with reduced efficiency and in addition the caked cement is liable to break or jar loose in large pieces and be discharged with the fresh concrete in which it forms a dangerous body.

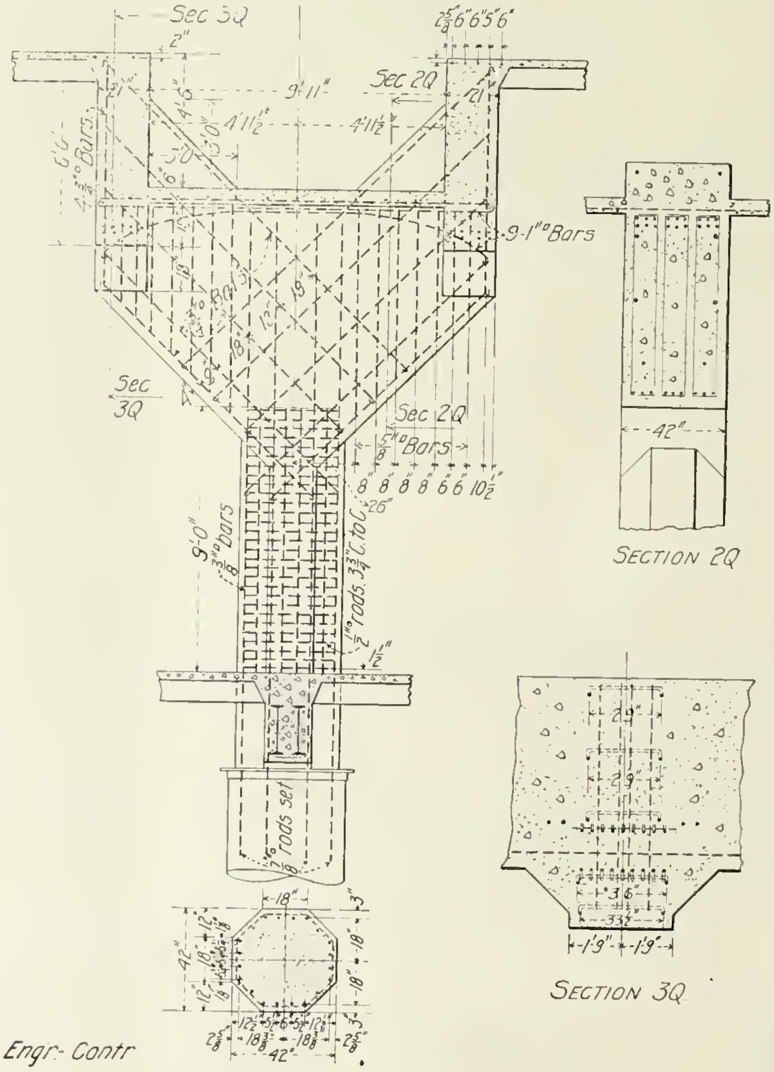
A Bracketed Column Design in Reinforced Concrete for Heavy Eccentric Loads.

The general features of the heavy reinforced concrete work for the mill of the Androscoggin Pulp Co., at South Windham, Me., were described and illustrated in Engineering-Contracting for Feb. 3, 1909. As stated then the striking detail of this concrete work was the large reinforced girders supported by bracketed columns for carrying certain of the heavy paper making machinery. We show by the accompanying drawing the detail of the bracketed column.

The construction consists of two 1-2-4 concrete beams, 78 ins. deep by 21 ins. wide, spaced 11 ft. 8 ins. on centers. These beams are reinforced with 7-8 in., and 1 in. square twisted steel tension bars and 3-8 in. round stirrups. A concrete slab spans between beams and in connection with them forms the machine pit which gives access to the underside of the machine and permits the weaving of the paper through the dryer rolls which span the pit.

Each beam supports a dead load of 56,000 lbs., is designed for a floor load of 59,000 lbs. and the live load of the paper machine, 48,000 lbs., or a total of 6,792 lbs. per lineal foot. The beams in themselves present no peculiar characteristics and are only noteworthy on account of their heavy loadings, but the supports for beams are of a special type and consist of octagonal I-1½-3 concrete columns with flaring Y-tops.

The Y-tops act as cantilever beams supporting the concrete girders above described at their extremities. Had the loading on each beam been equal at all times, the



Bracketed Column of Reinforced Concrete.

columns and cantilever tops would have been subjected to uniform stresses, but this is not the case, for the driving mechanism and the auxiliary apparatus for the paper machine are located on one side of the construction, hence excessive eccentric stresses exist in both the columns and cantilever tops.

The most severe strains are set up in the foot of the columns at the junction with the basement floor. here the maximum concentrated load will be 400,000 lbs. or 271 lbs. per sq. in., if evenly distributed, but the eccentric loading induces a moment which causes a fibre stress of 900 lbs. per sq. in. in the concrete on one face and it is to resist this stress that the ½-in. round hoops are employed.

A Method of Mixing Concrete by Hand.

There are several ways of mixing concrete by hand, any one of which will give good results in quality of mixture and economy of product. In a bulletin recently published by the Association of American Portland Cement Manufacturers, Mr. Percy H. Wilson and Mr. Clifford W. Gaylord describe in detail a way which they have found to be easy and efficient. Their description contains data of general value, and we publish the main parts of it here:

The way of mixing concrete by hand described here we believe to be the one best calculated to obtain good results with a minimum of labor. In this description and the accompanying illustrations, we have taken as a basis a two-bag batch of 1:2:4 concrete.

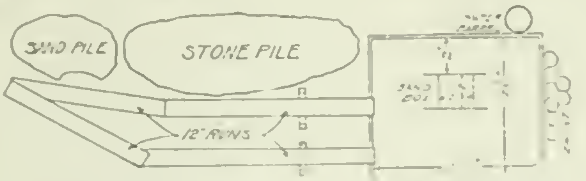


Fig. 1—Lifting Off Sand Measuring Box and Getting Cement Ready.

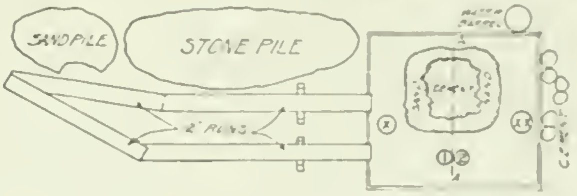


Fig. 2—Spreading the Cement Over the Sand.

Mixing Board.—A mixing board for two men should be 9x10 ft. Make it out of 1-in. boards, 10 ft. long, surfaced on one side, using five 2x4-in. x 9-ft. cleats to hold them together. If 1x6-in. tongue and groove roofers can be obtained, they will do very nicely if fairly free from knots. The object of the surfaced boards is to make the shoveling easy. The boards are so laid as to enable the shoveling to be done with, and not against, the cracks between the boards. The boards must be drawn up close in nailing, so that no cement grout will run through while mixing. Knotholes may be closed by nailing a strip across them on the under side of the of the board. It is a good precaution against losing cement grout to nail a 2x2-in. or 2x4-in. piece around the outer edge of the board. Often 2-in. planks are used in making concrete boards, but these are unnecessarily heavy and very cumbersome to move.

The concrete board is a manufacturing plant, and the advantages of its location should be carefully considered. Generally it is best placed as close as possible to the forms in which the concrete is to be deposited, but "local conditions" must govern this point. Pick a place giving plenty of room, near the storage piles of sand and stone (or pebbles). Block up your concrete board level, so that the cement will not run off on one side, and so that the board will not sag in the middle under the weight of the concrete.

Runs.—Do not use any old boards that are handy for the wheelbarrow runs. Make a good run, smooth, and at least 20 ins. wide if much above the ground. It is surprising how this one feature will lighten and quicken the work.

Tools and Plant.—The following is a list of tools and plant to be used in mixing, giving sizes, quantities, etc.:

Concrete Board for 2-Bag Batch, 9x10 ft. in size:
- 9 pcs. ⅞"x12"x10', surfaced on one side and two edges. (Any width of plank may be used; 12" is specified only for convenience.)
- 5 pcs. 2"x4"x 9' rough.
- 2 pcs. 2"x2"x10' rough.
- 2 pcs. 2"x2"x 9' rough.

Concrete Board for 4 Bag Batch, 12x10 ft. in size:
- 12 pcs. ⅞"x12"x10', surfaced one side and edges. (Any width of plank may be used, 12" is specified only for convenience.)
- 5 pcs. 2"x4"x12' rough.
- 2 pcs. 2"x2"x10' rough.
- 2 pcs. 2"x2"x12' rough.

Runs.—2", 2½", or 3" plank 10" or 12" wide.

Measuring Boxes for Sand and Stone or Gravel.

For 2 Bag Batch 1-2-4 Mixture:
- 1 pcs. 1"x11½"x2' rough.
- 2 pcs. 1"x11½"x4' rough.
- 2 pcs. 1"x11½"x6' rough.

Note.—The 2 pcs. 4' long and the 2 pcs. 6' long have an extra foot in length at each end to be made into a handle.

For 2 Bag Batch 1-3-6 Mixture:
- 2 pcs. 1"x11½"x2'.
- 2 pcs. 1"x11½"x3'.
- 2 pcs. 1"x11½"x5'.
- 2 pcs. 1"x11½"x6'.

Note.—The 2 pcs. 5' long and the 2 pcs. 6' long have an extra foot in length at each end to be made into a handle.

For 4-Bag Batch, double the contents of boxes and order lumber accordingly.

Shovels.—No. 3 square point.

Wheelbarrows.—At least two necessary for quick work; sheet iron body preferred.

Rake.

Water barrel.

Water buckets—2 gallon size.

Tamper—4"x4"x2'6" with handles nailed to it.

Garden spade or "spading" tool.

Sand Screen—Made by nailing a piece of ¼" mesh wire screen 2½'x5' in size to a frame made of 2"x4".

Mixing.—With the mixing board placed and the "runs" made the concrete plant is ready.

First load your sand in wheelbarrows from the sand pile, wheel on to the "board," and fill the sand-measuring box, which is placed about 2 ft. from one of the 10-ft. sides of the board, as shown by the diagram in Fig. 1. When the sand box is filled, lift it off and spread the sand over the board in a layer 3 or 4 ins. thick, as shown in Fig. 2. Take the two bags of cement and place the contents as evenly as possible over the sand. (See Fig. 2.) With the two men at points marked "x" and "xx" on the sketch below Fig. 2 start mixing the sand and cement, each man turning over the half on his side of the line *A A*. Starting at his feet and shoveling away from him, each man takes a full shovel load, turning the shovel over at the points marked 1 and 2 respectively in Fig. 2. In turning the shovel, do not simply dump the sand and cement at the points marked 1 and 2 in the diagram under the cut, but shake the materials off the end and sides of the shovel, so that the sand and cement are mixed as they fall. This is a great assistance in mixing these materials. In this way the material is shoveled from one side of the board to the other, as shown in Figs. 3 and 4. Fig. 3 shows the first turning, and Fig. 4 the second turning.

The sand and cement should now be well mixed and ready for the stone and water. After the last turning spread the sand and cement out carefully, place the gravel or stone measuring box beside it and fill from the gravel pile. Lift off the box and shovel the gravel on top of the sand and cement, spreading it as evenly as possible. With some experience equally good results can be obtained by placing the gravel measuring box on top of the carefully leveled sand and cement mixture, and filling it, thus placing the gravel on top without an extra shoveling. This method is shown in Fig. 6. Add about three-fourths the required amount of water, using a bucket and dashing the water over the gravel on top of the pile as evenly as possible. Be careful not to let too much water get near the edges of the pile, as it will run off, taking some cement with it. This caution, however, does not apply to a properly constructed mixing board, as the cement and water cannot get away. Starting the same as with the sand and cement, turn the materials over in much the same way, except that, instead of shaking the materials off the end of the shovel, the whole shovel load is dumped as at points 1 or 2 in the diagram under Fig. 2 and dragged back toward the mixer with the square point of the shovel. This mixes the gravel with the sand and cement, the wet gravel picking up the sand and cement as it rolls over when dragged back by the shovel. Add water to the dry spots as the mixing goes on until all the required water has been used. Turn the mass back again, as was done with the sand and cement. With experienced laborers, the concrete would be well mixed after three such turnings; but if it shows streaky or dry spots, it must be turned again. After the final turning, shovel into a compact pile. The concrete is now ready for placing.

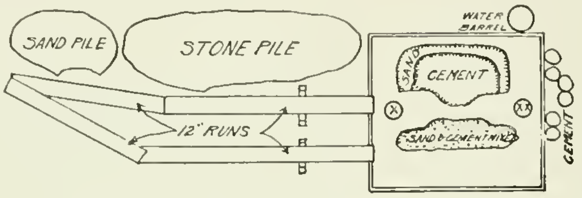


Fig. 3—First Turning, Cement and Sand.

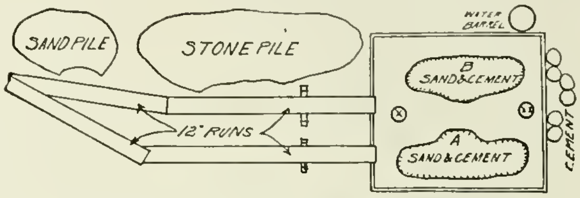


Fig. 4—Second Turning, Cement and Sand.

Mixing Natural Mixture of Bank Sand and Gravel.—Spread out the mixture of sand and gravel as much as the board will readily permit, add enough water to wet the gravel and sand thoroughly, spread the cement evenly in a thin layer over the sand and gravel, and turn over, as described previously, at least three times, adding the rest of the water necessary to get the required consistency while the materials are being turned. It requires some experience to work up a natural mixture of bank sand and gravel, and if at all doubtful about the concrete made from it, first screen the sand from the gravel and then mix in the regular way.

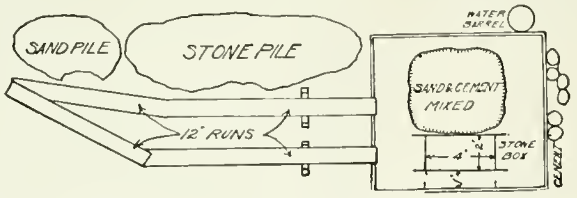


Fig. 5—Filling the Stone Measuring Box, First Method.

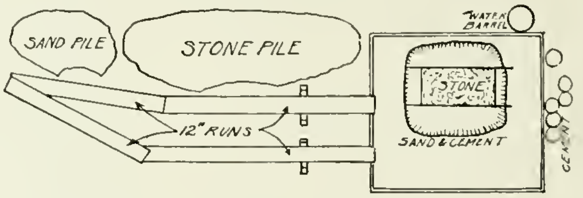


Fig. 6—Filling the Stone Measuring Box, Second Method.

Number of Men.—For the above operation only two men are required, although more can be used to advantage. If three men are available, let two of them mix as described above and the third man supply the water, help mix the concrete by raking over the dry or unmixed spots as the two mixers turn the concrete, help load the wheelbarrows with sand and stone or gravel, etc.

If four men are available, it is best to increase the size of the batch mixed to a four-bag batch, doubling the quantities of all materials used. The cement board should also be increased to 10x12 ft., as shown under "Tools." In this case start the mixing in the middle of the board, and each pair of men mixing exactly as if for a two-bag batch, except that the concrete is shoveled into one big mass each time it is turned back on to the center of the board. When more than four men are available, the rest may place the concrete, make new runs, load wheelbarrows, etc., taking the concrete away from the board as fast as it is mixed. In this case another small concrete board should be placed next to the big "board," so that in the last turning the batch can be shoveled over on to the small board for placing, making room on the big board to mix the next batch. The small platform need be only just big enough to hold the pile of mixed concrete.

When the day's work is done, carefully clean all the tools, especially the concrete board. Remove with a shovel all the loose cement, sand, and stone. Then scrub the board with a broom and water. If this is not done, small particles of stone are glued to the board by the cement, and render shoveling the next day most difficult.

With a little practice, the sand and stone or gravel can be measured by the number of wheelbarrow loads about as accurately as by the measuring boxes.

To determine quantities of materials needed, first figure the number of cubic feet of concrete that will be required for the work in question. Then by multiplying this number by the number under the proper column and required mixture shown in Table I, the amounts of cement, sand, and stone or gravel can be found.

TABLE I.
Quantities of Material in 1 Cu. Ft. of Concrete.

Mixture.	Cement, Barrel.	Sand, Cu. Yard.	Stone or Gravel, Cu. Yard.
1-2-4 Concrete...	.058	.0163	.0326
1-3-6 Concrete...	.041	.0174	.0348

Suppose the work consists of a concrete silo requiring in all 935 cu. ft. of concrete, of which 750 cu. ft. is to be 1-2-4 concrete, and 185 cu. ft. is to be 1-3-6 concrete. Also enough sand and cement is needed to paint the silo inside and outside, in all 400 sq. yds. of surface, with a 1-1 mixture of sand and cement. One cubic foot of 1-1 mortar will paint about 15 sq. yds. of surface and requires 0.1856 barrel of cement and 0.0263 cu. yd. of sand.

CEMENT—	Bbls.
Cement for the 750 cu. ft. of 1-2-4 concrete is 750 × .058...... =	43.5
Cement for the 185 cu. ft. of 1-3-6 concrete is 185 × .041...... =	7.6
Cement for painting........ .... 400/15 × .1856..... =	4.9
Total cement	56.0
SAND—	Cu. yds.
Sand for the 750 cu. ft. of 1-2-4 concrete is 750 × .0163... =	12.25
Sand for the 185 cu. ft. of 1-3-6 concrete is 185 × .0174.... =	3.25
Sand for painting........ .... 400/15 × .0263.... =	.75
Total sand	16.25
STONE OR GRAVEL—	Cu. yds.
Stone or gravel for the 750 cu. ft. of 1-2-4 concrete is 750 × .0326.. =	24.5
Stone or gravel for the 185 cu. ft. of 1-3-6 concrete is 185 × .0348.. =	6.5
Total stone or gravel............	31.0

Thus the necessary quantities of materials are: 56 bbls. of Portland cement; 16¼ cu. yds. of sand, and 31 cu. yds. of stone or gravel.

It is always wise to order two or three extra barrels of cement, if the dealer is at considerable distance, as this avoids any possible trouble that a shortage might cause. Besides, any cement left over always comes in handy for repair work around the house or barn.

Earth and Rock Section

Note: This Section is devoted to methods and costs of excavating earth and rock and building embankments. It will cover the grading of roads and railroads, diking and canal work, dredging, building reservoirs and earth dams, sewer and water pipe trenching, quarrying, etc.

The Methods and Cost of Laying Small Gas Mains on Six Jobs

BY W. H. MATLOCK

In this article the cost is given of laying 4-in., 6-in. and 10-in. gas mains on 6 different jobs, there being a total of 10,921 lin. ft. of pipe laid. The 10-in. main was first laid, the 6-in. and 4-in. following. The work was done in the months of May and June, 1908. The weather during that spring was unusually wet and all costs are a little higher than they should be, yet the tables will give a fair idea of what work will cost under such conditions.

The ditch averaged 3 ft. 6 ins. in depth and was 28 ins. wide. The soil was half and half sandy clay and gumbo, with the exception of about 150 ft. of quicksand encountered in laying the 10-in. line. The 10-in. line was almost all laid on rainy days in a wet ditch. From 1,500 to 2,000 ft. of the ditch were one-third full of water at one time, which caused it to cave, and about 900 ft. had to be redug, aside from bailing the water with buckets from some 2,000 ft. of it.

A creek was crossed with the 10-in. line. Fig. 1 shows method of crossing it. Here lead joints were used, but all other joints on the six jobs were made with cement. The following fittings were put in on the 10-in. line: Three 10-in. drips, thirteen 5-in. tees, one 10-in. cross, and one 10x6-in. reducer.

The 6-in. line No. 1 was laid next and under similar conditions, and the following fittings used: Three 6-in. crosses and three 6x4-in. tees.

The 4-in. lines were put in when the weather was good and the soil dry. Records kept in laying the 4-in. pipe showed that 3 ft. of yarn would make four joints and that one sack of cement would calk and cap 32 joints. Lehigh Portland cement was used, and tests previously made showed tensile strengths of from 500 to 600 lbs. per sq. in.

The gang averaged 25 men. The last day's work consisted of 52 lengths of 6-in. pipe and 29 lengths of 4-in. pipe, the ditch being opened, pipe laid and calked in 10 hours. In back-filling the trench the earth was hand tamped in from 6 to 8-in. layers. The team was used in handling pipe and other supplies from the plant to the job, an average distance of two miles.

The following wages were paid: Foreman 27½ cts. per hour; calkers 22 to 25 cts. per hour; laborers 17 cts.; team and driver 45 cts.; watchman 17½ cts., and water boy 15 cts. per hour. A night watchman was employed throughout the job and a man for Sundays.

The cost of the work, divided into various items of labor for each lineal foot, is shown in Tables I and II.

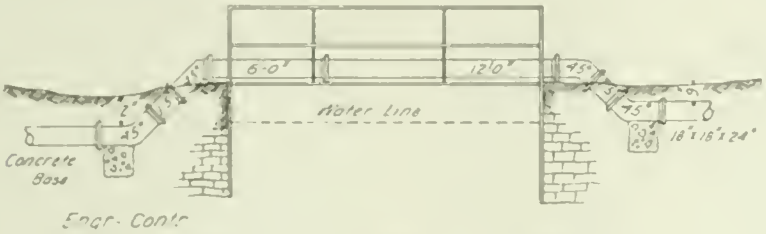


Fig. 1—Sketch Showing Method of Crossing Creek.

TABLE I

Job No.	"A"	"1"	"2"
Size	4 in.	6 in.	10 in.
Total ft. laid	1,112	1,302	5,781
Team and driver	$0.007	$0.011	$0.023
Foreman	0.007	0.005	0.007
Superintendence		0.005	0.007
Excavation	0.040	0.033	0.058
Caulking	0.004	0.007	0.012
Back filling	0.040	0.032	0.058
Sundry expenses		0.002	0.006
Total cost per ft.	$0.098	$0.096	$0.171

The sundry expenses [illegible] are for the watchman and water boy.

All the pipe was tested before going into the ditch and all leaky [illegible] were cut out and replaced. There were 18 [illegible] on the 10-in. line due to [illegible] good joints. After the pipes were all laid they were all tested. The 10-in. line was tested in four parts. The others were tested once. This testing, which was all in the air, was done with an old style hand pump that required 10 men to operate. In testing 12 men were used, 10 to pump up the line, 1 to [illegible] joints, and 1 to look after the gage. The time consumed by a test varied from 15 mins. to 1½ hrs. This time is distributed as well as possible between the laborers and calkers, as all took a hand.

After completing the work a final test was made, as shown by Fig. 2. The piping was placed and a meter set; the pressure was then equalized by running gas from an old 10-in. line through the 4-in. line and into the new line, this line being opened at *B* for 15 mins. At the end of this time *B* was closed and *A* opened, allowing the gas to pass through the meter and to register. After the register was made, which took almost 10 mins., the meter was read and noted, then left standing for 2½ hrs. At the end of that time it was reread and finding the reading to be the same as at the time of the first registering, it was known that no gas had passed through the meter, hence there were no leaks in the new line. The following day men were sent along the line and all drip heads were opened, allowing all air to pass out.

Bids are again being asked by the U. S. Navy Department for the construction of a dry dock at the Naval Station at Pearl Harbor, Hawaii Territory. Bids for the construction of a 1,200-ft. long dock at this station were opened on Dec. 1, but were rejected owing to lack of sufficient funds to construct such a dock. A revision of the plans limiting the dock to 620 ft., therefore, has been made. The structure will be built in such a way that at any future time it may be lengthened by the addition of the inner dock. To accomplish this the side walls of the dock will be built exactly as if the long dock were to be constructed, and a concrete wall will be built across the head end forming a closed basin. This concrete cross wall or head is to be made in such a manner that it can be easily removed.

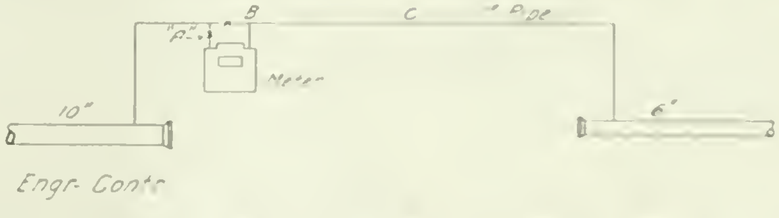


Fig. 2—Sketch Showing Method of Making Tests.

TABLE II

Job No.	"B"	"C"	"D"
Size	4 in.	6 in.	6 in.
Total ft. laid	595	841	993
Team and driver	$0.009	$0.011	[illegible]
Foreman	0.009	0.034	[illegible]
Superintendence		0.005	
Excavation	0.052	[illegible]	[illegible]
Caulking	0.007	[illegible]	[illegible]
Back filling	0.050	0.135	[illegible]
Total cost per ft.	$0.127	[illegible]	$0.137

Cost of Drilling Blast Holes By Hand With a Churn Drill.

In drilling blast holes in the stripping of iron ore on the Mesabe Range, Minn., in many cases the holes are drilled by men with long churn drills. The stripping is done and the ore is excavated by means of steam shovels. Even where the material is soft enough to be dug by the shovel direct, it makes quicker work to have the banks first loosened by explosives.

The stripping is done as a rule in lifts of from 20 to 30 ft., until near the ore, when the "clean up cut" is made from 6 to 10 ft. In the ore, cuts are made from 10 to 25 ft. deep, depending on the grade of tracks, and the particular part of the ore body being excavated. In most cases 90-ton steam shovels with 2½ cu. yd. dippers are used for both stripping and mining operations.

The holes for blasting are bored to the depth of the steam shovel cutting on a 20-ft. lift. High lifts are not worked much on account of the banks caving in on the shovel, thus sacrificing efficiency in shovel operation to safety of men and machinery; the holes are placed about 20 ft. apart, staggered along the bench, two abreast. The drills are of 1-in. to 1¼-in. octagonal steel, with 1½-in. bits, and are operated by from 2 to 4 men, according to depths reached. The drills are lifted by means of a movable steel cross piece or arm, one for each pair of men. The cross piece is held to the drill by wedges. A small boulder is squibbed, but a large boulder is drilled.

In the stripping, one man averages 10 ft. of hole in 10 hrs. In ore, 24 ft. per man are drilled per day. With 4 men in a gang, and with wages at $2 per day, the cost of drilling for labor for 40 lin. ft. of hole is $8, or 20 cts. per lin. ft. This gives a cost of about 1⅓ cts. per cu. yd. In a 24-ft. bench of ore, the cost of drilling per linear foot of hole is 8 cts. This makes a cost of ⅜ ct. per cu. yd.

These costs are very reasonable for hand work, but it would seem that they could be reduced by using a blast hole drilling machine. The cost of operating such a machine per day would be about $8 (see Engineering-Contracting, Sept. 9, 1908, p. 165), made up as follows:

Driller	$3.00
Helper	2.00
Coal, water, etc.	1.50
Int., depreciation and repairs	1.50
Total	$8.00

Assuming that the machine would drill but 40 ft. per day in stripping, the cost would be the same as for hand work, but such a machine would drill from 50 to 60 ft. per day in such material, thus reducing the cost. Many of these machines are used in the Lake Superior district and have proved economical. In view of the fact that in these regions labor is often scarce, it seems strange that the hand method of churn drilling should be continued.

Method of Recovering a Diamond Drill.[*]

BY CLARENCE M. HAIGHT.

Recently in putting in a diamond drill hole on the property of the Michigan Copper Mining Company, Rockland Mich., a breakage occurred, that was dealt with in a peculiar manner, and, in view of the importance of diamond drilling as a means of prospecting, the following note may be of interest. The mode of procedure was original, in so far that no one connected with the drill work at the mine had ever seen or heard of a similar solution of the problem.

A nearly horizontal prospecting hole was being drilled from a point in one of the underground workings. The machine was a Sullivan, of the "H" type, taking out a 1⅛-in. core. The core-shell had become worn thin by use, so that, at a depth of 460 ft., it buckled under the working pressure of the rods and jammed in the hole.

The first step was to get the drill-rods out of the hole. Jack-screws were applied at the mouth of the hole to a gland bolted on the rods, sufficient strain being applied to break off the core-shell close to the core-lifter. It was found that the force required for this stretched the 460 ft. of rods 6 ins. Next, the stump of core left in the hole had to be removed. As a chopping-bit could not be used for this purpose, without great risk of injuring the diamonds, a special tapering bit was made, as shown by Fig. 1. The larger end of this bit fitted closely enough in the hole to center and guide the boring end in grinding out the core. This done, the bit was replaced by a taper tap, with which the core-lifter was recovered.

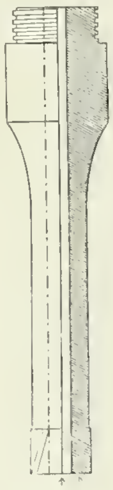


Fig. 1.

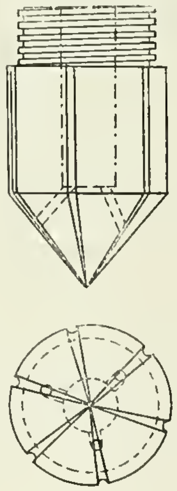


Fig. 2.

Finally, a pointed drill (Fig. 2) was made of tool steel, properly tempered, and put on the rods. With this the remains of the broken core-shell, together with a portion of the original diamond bit, were cut away until the bit itself was loosened in the hole. What was left of the bit, though only 1-in. long, was then easily recovered by a tap, and the diamonds were found to be uninjured. In using the pointed drill (Fig. 2), great care had to be taken to avoid running into the diamonds. To this end, the feed of the drill was accurately measured while the cutting was in progress. On recovering the bit it was found that there was still a margin of ⅜ in. of steel above the first diamond.

Method and Cost of Shore Protection by Revetment, Missouri, Kansas & Texas Railway.[*]

The revetment put in by the Missouri, Kansas & Texas along the Missouri River, for shore protection, is built like that along the Missouri River, which have been put in by the Missouri River Commission, and averages about 60 ft. in width. The first work put in by this company was during 1897, and extends from the east city limits of St. Charles down the river for 9,000 ft. A rock dike was first built out into the river, and a boom made of heavy timbers was anchored to the lower side of the dike, and laid parallel with it. From this boom the mat was started, having its full width at the beginning. The mat was first woven and sunk, and then the bank was graded by hydraulic power to a slope of 2 to 1, and then paved from the top down.

In 1903, work was extended 3,000 ft. down the river, and was done in the same way as the first section, with the exception that the mat was anchored at the starting point with piles instead of the boom.

In 1906, revetment was again extended 7,200 ft. On this last section the bank was graded to a slope of 2½ to 1 in advance of weaving the mat, as considerable trouble had been experienced on former work, on account of material from the bank covering the mat, so that a connection between paving and mat could not be properly made.

Grading on this section was done with a small hoisting engine on a barge, as follows: A derrick was erected on a barge, having a boom long enough to reach the top of the bank to be graded, a No. 3 wheeler scraper pan was pulled along this boom from the barge to the top of bank, by a mule on the bank, and was held in place by two men and filled, and then dragged down the bank by the hoisting engine. The beginning of the mat was anchored to deadmen on top of the bank about 200 ft. up stream, and weaving was begun about 100 ft. back on the old mat, so that the full width of the new mat was gotten where the unprotected bank commenced.

In 1908, 4,000 ft. of revetment was put on the north side of the river just above Boonville bridge. At Kingsbury, there is a siding on the west side of main line, and out of the south end of this track the spur was built to the river; this required a main track 6,500 ft. in length, and a spur track 900 ft. in length. Track was laid about 5 to 20 ft. from top of bank all along where revetment was to go in, so that rock could be unloaded and used with as little handling as possible. The bank was first graded to a slope of 2½ to 1 by teams; the mat was then woven and sunk, and the slope paved from bottom up. It is the description of this last section that will be given, as the only differences between this and other works are those mentioned.

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[*] Reprinted from the "School of Mines Quarterly."

[*] Description of work by R. M. Garrett, Resident Engineer, given in the report of the Committee on Roadway to the American Railway Engineering and Maintenance of Way Association.

The bank was about 18 ft. higher than what was taken as the average low water; the soil is mostly a very fine sand and very little gumbo; the bank was clear of timber and brush, but there were several large snags where the mat was to lay that were taken out by sawing, blowing out and using teams and line.

Shovelers first dug along the top of the bank and shoveled down all the perpendicular and overhanging points, so as to make it safe for a mule to walk along close to the edge; then a two-mule team plowed two or three furrows as close to the edge of the bank as team could be gotten. The mules were then hitched to a "go-devil," constructed of two 2x10 in. plank 8 ft. long, fastened together at the front end and flared to about 4 ft. at the back end. It required one man to drive the mules and one man to weigh the drag. This was then run along the back side of furrows, and the loose earth shoved toward the river. After the bank began to slope, two or three slips were put on, and the bank brought to the desired slope.

It will be seen that only about half of the material in slope is moved, as the excavation makes the fill and does not wash away, as it does when grading by hydraulics. It was found that with this material the filled portion was as solid as the natural surface. Grading was never carried farther than 200 ft. in advance of weaving, as the barges from which the mat was being woven would protect the bank from the current for this distance.

The mat was woven 60 ft. wide with a selvage edge on the out stream side, and sunk parallel with the shore with the inner edge about 3 ft. above the average low water. The mat was strengthened with five double rows of 5/8 in. galvanized steel cable—7 strands of No. 11 wire—laid longitudinally, one above and one below, and anchored with a double row of similar cable laid transversely every 15 ft. and fastened to deadmen, buried 3 ft. deep and located 15 ft. back from the upper edge of slope. At every intersection of the longitudinal with the transverse rows, the four cables are fastened together with a 5/8 in. U clip. The transverse rows are fastened to deadmen by wrapping one cable around the deadman twice and then fastening it to the other cable with two 5/8 in. U clips. The deadmen are pile butts about 3 ft. long, and the object in fastening the cable to them as mentioned, is to allow the cables to slip when loaded, so that the same strain will be on both the under and upper cables. The willows were cut from bank of river about one mile above the mat, and were hauled by wagons, hauling about 1.6 cords to the load. The road was bad at times, and it required a snap team to pull out of the mudholes, but most of the time the road was in good shape. It required 0.6 cord of brush to 100 sq. ft. of mat; average thickness of mat, about 18 ins.

Weaving was started at a point at the upper end and gradually widened out to full width, anchors being placed for longitudinal cables in the top of the bank about 100 ft. above the upper end. The mat was woven with four small bags fastened together, so as to make the desired width. Fingers of skids were built on barges out of 3x12 in. plank, 21 ft. long, and spaced 5 ft. apart, extending from the water level on up-stream side to an elevation of 3 ft. above floor of barge at a point about 3 ft. back from down stream side. Spools of cable were set under the down-stream ends of the fingers at the proper position for the under longitudinal cables, so that cable would unwind as the barge was let down stream. The barge was anchored at the shore end to the track, and at the upper end to the mat that had been woven. The mat was woven on the barge as high as the fingers would permit, and cable and clip men would pull the under cables through the mat by means of an iron hook about 2 ft. long, and the top longitudinal cables were run under these, and all were fastened together with a 5/8-in. clamp. The barge was then pulled from under the mat with a team, and anchor ropes slacked just enough so that about 3 ft. of mat would be left on fingers. Top longitudinal cables were cut off of reel on shore in lengths of about 100 ft., and spliced together with a square knot on mat, as the work proceeded.

The mat was sunk and held down with stone weighing from 30 to 50 lbs. An average of 1.5 cu. yds. of stone being used per 100 sq. ft. of mat. Rock for sinking was unloaded from cars onto shoulder of slope and wheeled in wheelbarrows out onto the barge, anchored lengthwise across the mat, and dumped along the edge of barge. The mat was sunk from the shore side out, so that it would settle away from shore and the transverse cables would tighten up. Sinking was kept at least 100 ft. back from weaving barge to prevent pulling the mat off of barge. When the water was higher than the proper elevation for the shore side of mat it was parred out, so that in sinking it would settle to its proper position.

The rock for paving the slope was unloaded from cars onto slope and rolled down to the bottom, where paving was begun. Paving is 10 ins. thick, and was paved from the bottom up, care being taken to fill all the cracks with small stone. At the upper edge of paving spawls were piled so as to keep the surface water from washing under the paving and starting it to roll. As long as the water was low, a good connection was gotten between paving and mat, but there were parts of this work that were paved during high water, and the rock slid in afterward, making repairs necessary. The work done on the first section in 1897 is in very good shape today. The mat has rotted where it has been exposed to the air, but the paving is in good condition.

There have been some slides on the work done in 1906. At these places it was found that the rock was settling under the edge of the mat. These were places where the bank had washed after mat had been put in, and the mat does not lie up on the bank as it should.

Considerable trouble has been experienced on account of the eddy caused by the end of revetment. At Boonville bridge, the revetment ends at an old rock dike, and no difficulty is expected at that point, but at all of the other places it has given trouble. At the end of the work done in 1906 it is probably more noticeable. The revetment at this place was ended at a place where the bank extended out into the river 400 or 500 ft., and now the bank is 100 ft. farther in than the revetment, and the revetment has been repaired twice on account of the river washing behind the end, and allowing the rock to fall in.

The cost of the Boonville revetment is as follows: Cost per linear foot for 60 ft. mat. Banks 18 ft. above low water, laborers paid $1.50 per day, foremen $4, and teams, $3.50. This does not include interest on investment or make allowances for rainy days and moving, but is the actual cost. The contractor's profit is included in the track work only.

Item		Per lin. ft.
Grading bank, per lin. ft.		$0.13
Weaving mat		.110
Sinking mat		.110
Paving slope		.230
Willows, including cutting, hauling and unloading, and price paid land owner		.310
Rock at $0.75, delivered on site (2.3 cu. yds. to the lin. ft.)		1.730
Unloading rock		.120
Spotting cars with teams		.001
Hauling deadmen and cable		.018
Taking out snags		.030
Cable and Clips		
1250—5/8 in. clips at .06	75.00	
746—5/8 in. clips at .035	26.16	
10715.0—5/8 in. cable at .100	1071.50	
	1173.26	.300
Deadmen, 270 at .50 = $135.00		.035
Track, 7500 lin. ft.		
Labor, grading, including contractors' profit	1581.90	

Labor, laying	1493.20	
Taking up	1000.00	
	4075.10	
Bridge across draw	460.00	
	4535.10	1.140
Grading spur to quarry, $393.50		.074
Total cost per lin. ft.		$4.67

Cost of the Whalen Dike, North Platte Project.

The following tables, taken from the March Reclamation Record, show itemized estimates of the unit costs to the contractor of building an earth dike at Whalen, Wyo., and of backfilling around the headworks of the proposed Fort Laramie Canal. The work was performed during the period from October, 1908, to January, 1909, and the weather and labor conditions were generally favorable. In the coldest weather, however, some extra labor was occasioned by the necessity of plowing the borrow pits at night to prevent trouble from freezing. The wages paid were for foreman, $4 per day; teamsters, $0.22½ per hour; loaders and dump men, $0.25 per hour, and teams, $2 per day. The contractor was an experienced man in handling earthwork. The material was generally a sandy loam of the best quality for plowing and scraping.

The material for the main like, amounting to 22,598 cu. yds., was all taken from a borrow pit situated above the dam. The average haul was 600 feet and the material was moved mainly with wheel scrapers and Maney four-wheel scrapers. The backfilling for the Fort Laramie headworks, amounting to 4,550 cu. yds. was taken from a borrow pit below the dam. The average haul for this material was 1,000 feet and it was handled in two-wheel scrapers, the conditions not permitting the use of the larger wheelers.

Distribution.	Dike, 22,598 cu. yds. unit cost.	Backfilling, 4,550 cu. yds. unit cost.
Labor—		
Foreman	$0.014	$0.030
General work	.014	.017
Hauling	.124	.181
Plowing	.017	.044
Snap team and driver	.027	.036
Loading and placing	.029	.057
Total labor	.225	.365
Supplies	.002	.007
Blacksmithing	.001	.010
Total unit cost	$0.228	$0.382

According to a recent government report there are in Portugal 8,920 miles of macadamized roads and 2,461 miles in construction.

Roads and Streets Section

Note: This Section is devoted to methods and costs of road and street construction. It will cover road building in all its details, the construction of pavements, sidewalks and gutters, the testing and use of paving materials and the machinery and tools used in road building and paving.

Economic Hints for Macadam Road Contractors.

(Continued from March 24 issue.)

82. Bear in mind that, in repairing old macadam roads, much roller time may be lost due to stopping to permit teams to pass. In extreme cases the amount of time thus lost may be 50 per cent.

83. For repairing macadam a 12 to 15 ton roller is considered preferable by some road builders. If spikes are used in the roller to pick up the old macadam, a heavy roller is more effective than a light one. Furthermore, since there is no subgrade to be rolled when repairing macadam, a heavier roller is more effective. The English authority, Aitken, says that in repairing macadam, where a 3 or 4-in. course of new stone is laid on the old macadam road, a 15-ton roller will compact 66 tons (of 2,240 lbs. of stone) per day, a 12-ton roller will compact 50 tons, and a 10-ton roller will compact 40 tons. When working on hills they will compact less per day. This estimate, he says, is based on the assumption that about 15 mins. are lost every hour waiting to let teams go by. Aitken does not include the weight of the binder in the above estimate of weight of stone consolidated. Aitken says that 4 ton-miles of engine travel are required to compact each ton of broken stone on repair work. He says that in France 2½ ton-miles of engine travel are required per cubic yard of stone consolidated, the engine traveling at a maximum speed of 2½ miles per hour.

84. There are usually city ordinances that prescribe the conditions under which a steam roller may be moved from one part of the city to another Familiarize yourself with these, not only to avoid fine for violation, but to aid in your defense in case of lawsuit, due to accident from a runaway team.

85. If possible barricade the road or street that you are rolling and keep out all teams not in your employ. But, even if an outside teamster or driver takes down a barricade or disregards a sign, your roller engineman must stop his roller when the team draws near, or you will be rendered liable for any damage due to a runaway. Steam should be shut off when a strange team is near, for some horses are greatly alarmed by its hissing sound.

86. To prevent stealing of the brass parts etc, it is usually necessary to have a night watchman to protect the roller when not in use This additional expense should not be overlooked in estimating cost of rolling.

87. Many small highway bridges on unimproved roads are not strong enough to carry a 10-ton roller safely. Inspect all such bridges carefully before taking the roller over them. It is frequently necessary to put some wooden posts under a bridge to stiffen it during the passage of the roller.

88. A 10-ton roller will crush 12-in. vitrified pipe that is not buried more than 2 ft. deep. The writer had several hundred feet of such pipe crushed by a roller, although it was covered with more than 2 ft. of earth. The backfilling had not been rammed in layers, and it is likely that the pipe would not have been crushed at that depth had the backfill been rammed in thin layers.

89. The earth subgrade should usually be well rolled with the steam roller. Dry sand can not be compacted with a steam roller, but pushes in waves ahead of the roller.

90. A rolling tamper of the Petrolithic type is more effective for compacting a subgrade than any other tool. When a rolling tamper is used the subgrade must first be plowed, so that the tampers can sink to the hilt in the loose soil and start tamping from the bottom up. There is no bridging action where this tool is used, and no soft spots are left.

91. If much repairing of macadam is to be done, use a scarifier pulled by the roller, instead of using picks in the rear wheels of the roller. A roller used to break up old macadam by means of picks undergoes severe jolting which loosens the boiler tubes and shakes the rest of the machinery badly.

92. As road work is done in the summer when the days are long, a roller can be worked two 8-hour shifts, or 16 hours out of the 24, if enough stone is delivered to keep it busy. One shift will begin at 4 a. m., and extend till noon; the other shift will begin at noon and extend to 8 p. m., In such cases the engineman must not spend more than 15 mins. eating his lunch, during the period that the roller is taking on water and coal. A fireman can then be hired for night watchman, and no time will be lost by the engineman in the morning firing up.

93. In northern climates a roller seldom works more than 125 days a year, and the average is usually not much more than 100 days. Since a steam roller is a rather expensive part of a contractor's plant, it is particularly economic to work it two shifts daily. On the other hand, if a contractor has abundance of capital, the interest charge on the roller is not a large item per day, and the depreciation and repair item is light. A steam roller has a life of at least 25 to 30 years, when worked one shift

duty 100 to 125 days a year. Current repairs and depreciation distributed over the entire life of a roller will amount to less than 8 per cent of its first cost yearly. Current repairs during the first half of its life are very slight—about $75 to $90 a year.

94. At the end of the working season, remove all the brasses and other parts that might be stolen, and house the roller in a shed or barn that does not leak, after covering all bright parts of the machinery with a heavy coat of railroad car grease. Lay heavy planks for the wheels to rest on, if there is no floor in the shed.

95. Select an engineman for the roller who can make daily reports of progress and can serve as a foreman of the few men engaged in spreading the stone. There is no necessity of a regular foreman of these men.

96. If creek or river water for sprinkling can be had only by making a long haul, it is often possible to find water close at hand by boring small, shallow wells at intervals along the road. An examination of farm wells may indicate the possibilities of securing an adequate supply in this manner. Often it will pay to arrange with farmers to secure water from their wells.

97. A small gasoline pumping engine and a portable tank that can be mounted on legs or posts should be used to supply the sprinkler with water. If the driver of the sprinkler is required to pump the water, the team will lose much of its time waiting for the sprinkling cart to be filled.

98. One workman with a good hand pump can pump 1,000 cu. ft. (or 7,500 gals.) of water to a height of 16 ft. in 10 hrs. Since about 8 cu. ft. of water are often used per cubic yard of macadam, and since 40 cu. yds. of macadam (measured rolled in place) constitutes the average day's work of a roller there may be required 320 cu. ft., or 2,400 gals. of water per day for sprinkling. This does not represent enough work to keep a laborer constantly busy pumping into a tank, yet it represents too much work for a teamster to do when the lost time of his team is considered.

99. A sprinkler holding 20 cu. ft., or 150 gals., can be loaded in 10 mins. from a tank, and it will discharge its load in about the same time. Hence, by figuring on a speed of 220 ft. per minute, or 2½ miles an hour, traveling between the tank and the place of delivery on the road, it is easy to estimate how many sprinkling wagons will be needed.

100. If two or more rollers are being worked at the same time, it will frequently pay to have an extra sprinkling wagon which is being loaded with water while the loaded wagon is being hauled to the road. Not only is team time saved in this manner, but if the extra wagon is being loaded with water by a man using a hand pump, there is no necessity of providing a stationary tank.

101. If water hauls are long it is usually wise to have 4 to 6 horses hitched to a large tank wagon. Even with moderate hauls, this is the common practice in California. 1,000 gallons in a tank wagon is readily hauled by 6 horses over fairly good earth roads.

(To be continued.)

Macadam Construction with Asphaltum Binder in New Jersey.

During the past year a number of experiments were conducted in New Jersey under the direction of the State Commissioner of Public Roads on the use of heavy asphaltum oil as a binding substance in macadam road construction. Specifications have just been issued by the State Commissioner covering the use of asphaltum binder in macadam construction.

The sections of the specifications that refer particularly to the macadam construction and asphaltum binder are as follows:

After the road-bed has been formed and rolled as above specified, and has passed the inspection of the engineer and supervisor, the first layer of broken stone, consisting of 2½-in. stone, or stone that will pass through a ring 3 ins. in diameter, shall be deposited in a uniform layer, having a depth of .... inches, and rolled repeatedly with a 10-ton standard steam macadam roller until compacted to the satisfaction of the engineer and supervisor. No stone in this course shall be less than 2 ins. in length.

The depth of loose stone in this and all other courses must be measured by blocks the required thickness of the said loose stone. These blocks must be placed at frequent intervals amid the loose stone when being spread.

On the first course of stone a quantity of stone screenings shall be spread in a uniform layer, and the whole rolled until the stone ceases to sink or creep in front of the roller, the quantity and quality of this binder to be subject to the approval of the engineer and supervisor. Gravel found along the line of the road or furnished by the contractor of a quality approved by the engineer, shall be used in addition to the stone screenings as a binder. The quantity and manner of applying the gravel to be subject to the approval of the engineer and supervisor, but no binder shall be applied in sufficient quantity to completely cover or form a coating upon this course of stone.

The second course of broken stone shall consist of 1½ in. stone, that is, every piece of stone shall be broken so that it can be passed through a ring 2 ins. in diameter, and no stone shall be more than 2 ins. or less than 1 in. long. This course shall be spread in a uniform layer having a depth of .... inches and rolled with a ten-ton standard steam macadam roller until thoroughly settled into place to the satisfaction of the engineer and supervisor. Dry, clean, sharp sand, free from loam or clay, shall then be spread in sufficient quantity to fill 50 per cent of the voids, and the whole re-rolled until the sand is [illegible] showing below the surface at any point on stone.

The contractor will not be allowed to spread the second course of broken stone until he is ready to apply the asphaltum binder, as hereinafter specified, immediately after the course of stone is properly prepared. When so prepared and until the final rolling the contractor must protect that portion of the roadway from all unnecessary travel that will tend to destroy the desired crown of the macadam.

When the second course of broken stone has been spread and rolled as above specified, asphaltum binder shall be applied by means of a mechanical distributer designed to evenly distribute the asphaltum binder, to regulate the width of distribution, to control the quantity distributed and to maintain the asphaltum binder at a uniform temperature.

The quantity of asphaltum binder required will be about . .. gallons per sq. yd. of macadam surface, and the temperature of the same when applied shall be not less than 150 degrees F. or more than 200 degrees F.

After the application of the asphaltum binder a quantity of dry, clean, sharp sand, free from loam or clay, shall be spread in a uniform layer and of sufficient depth to prevent the stone adhering to the wheels of the roller. The rolling, together with the spreading of additional sand to take up the surplus asphaltum binder forced to the surface, shall continue until the stone ceases to sink or creep in front of the roller. The quantity and quality of the sand, together with the amount of rolling required to be done, shall be subject to the approval of the engineer and supervisor.

Any depressions formed during the rolling, or from any other cause, are to be filled with 1½ in. stone or ¾ in. stone or both, together with asphaltum binder and sand, as ordered by the engineer, and the roadway, when rolled, brought to the proper grade and curvature as determined by him. Additional asphaltum binder must also be applied in such quantities and at such points as directed by the engineer, so that the entire surface of the second course of stone will show a uniform quantity of asphaltum binder upon its face before the spreading of the surface course of stone.

When the two courses of stone are rolled to the satisfaction of the engineer and supervisor, a coat of 50 per cent of ¾ in. stone and 50 per cent of stone dust properly mixed, shall be spread of sufficient thickness to make a smooth and uniform surface to the road and to absorb any excess of asphaltum binder that may be brought to the surface of the road at any time and from any cause, then again rolled until the road becomes thoroughly consolidated, hard and smooth.

Rolling must be done by contractor with a ten-ton standard steam macadam roller, so constructed as to give a compressing power of not less than 400 lbs. per lin. in on drivers, approved by the engineer.

In the rolling the roller must start from the side lines of the stone bed and work towards the center, unless otherwise directed. The rolling shall at all times be subject to the directions of the engineer and supervisor, who may, from time to time, direct such methods of procedure as in their opinion the necessities of the case may require.

No water will be allowed in the construction of the macadam work. The stone to which the asphaltum binder is to be applied must be dry at the time the application is made, and should there be a shower or heavy dew this part of the work must stop until the stone has thoroughly dried.

All stone must be as nearly cubical as possible, broken with the most approved modern stone-crushing machinery, free from all screenings, earth and other objectionable substances, of uniform size, and the same kind and quality, or equally as good in every particular, as that shown in the engineer's office. The 1½ in. stone, ¾ in. and dust for binder and final finish must be of the best trap-rock, free from loam or clay.

Asphaltum binder must conform to the following requirements and tests:

(1) Specific gravity, with binder at a temperature of 60 degrees F., not lighter than 13.5 Baumé.

(2) Bitumen soluble in carbon di-sulphide, not less than 99.5 per cent.

(3) Loss in weight, after heating twenty grams of the binder, in a tin box two and one-quarter inches in diameter and one inch deep, to 325 degrees F., and maintained at this temperature for a period of five hours, not more than 1 per cent.

(4) When the binder is evaporated at a temperature not exceeding 500 degrees F., it must give not less than 90 per cent. of a residue having a penetration of one hundred (Dow machine) at 77 degrees F.

(5) When a 6-in. test tube, having an inside diameter of 1 in., is filled half full of the binder, cooled to and maintained at 50 degrees F. for a period of 30 minutes, then brought to and maintained at 65 degrees F. for a period of 30 minutes, it must at that temperature (65 degrees F.) show a flow perceptible to the eye in 30 seconds. The binder, after cooling to 50 degrees F., is not to be stirred or agitated in any way before or during the flow test, and, after being cooled to 50 degrees F., it must not be heated to a temperature exceeding 65 degrees F. until after its flow has been determined.

(6) An asphaltum binder that does not comply with the above requirements and yet has been in successful use for more than one year in a road constructed by the method and with the road metal herein specified and under similar climatic conditions, may be accepted, provided satisfactory proof of its successful use is submitted by the bidder to the engineer and State Commissioner of Public Roads.

Concrete Pavement Construction at Bozeman, Mont.*.

BY C. M. THORPE.†

Bozeman is a small city of about 10,000 population, situated in the famous Gallatin Valley.

The matter of improving our main street has been discussed for ten or fifteen years. Plans were made in 1893 for macadamizing the street, but the proposition was voted down. In 1907 the city council created an improvement district for the purpose of paving with creosoted wood blocks on a concrete foundation. This was objected to and defeated by the property owners, who objected to the cost and wished further time to investigate. A committee of property owners was then appointed to carry on investigations and report to the city council the kind of pavement they desired. These investigations were continued by the committee and city engineer until early in 1908, when the committee reported unanimously in favor of concrete pavement.

Plans and specifications were at once prepared and bids asked for. In preparing specifications it was thought best to ask each bidder to submit the details of construction with his bid, as it was claimed that a patent had been granted on concrete pavement. The bids were opened July 2, 1908, and a prominent construction company of Salt Lake City, Utah, was found to be the lowest bidder and the contract was awarded to it at the following prices:

For excavation, 50c per cu. yd.; for gravel fill, $1.25 per cu. yd.; for concrete pavement (not including excavation or gravel fill), $1.95 per sq. yd.

The principal points in the construction of the pavement are these: The street was excavated and rolled with a ten-ton roller; 3 ins. of fine gravel was then placed on the rolled surface where so required by the engineer; where the foundation was found to be gravelly no gravel fill was required. The forms were then set. These consisted of 2x7 in. plank, set with the top to grade and running across the street from curb to curb where there was no street railway track. Along the street railway track one side was constructed at a time. These forms were set 10 ft. apart and steel headers set 10 ft. apart between the forms, making blocks 10 ft. square. The foundation was then gauged to 7 ins. below grade and 5½ ins. of concrete deposited in every alternate space and the same well tamped. The concrete consisted of one part Portland cement and six parts natural gravel; where the sand was found to be in the right proportion the gravel was limited to 2 ins. in diameter.

Before the concrete was set the top, or finish coat, 1½ ins. thick, was placed thereon and troweled into the concrete. This top coat consisted of one part cement, one part crushed boulders or pea gravel and one part sand, the crushed stone or pea gravel being limited to ½ in. diameter and the sand being coarse and as clean as could be obtained.

The wearing surface was marked off into squares 4x8 ins., with grooves about ¾ in. deep, made by using a plank, one edge of which was shod with an iron the shape of the groove. This marker was used by two men and pounded into the wet concrete with wooden mallets to make the groove. The surface was then brushed with a brush and left quite rough. The grooves, 4 ins. apart, run across the street at right angles to the curb, and the grooves, 8 ins. apart, are parallel with the curbs. It was allowed three weeks for setting before being opened for travel, during which time it was covered with sand and kept wet. Expansion joints were run across the street every 100 ft. and also along the curbs. These were filled with asphalt compound. The concrete and top coat was all mixed with two Smith mixers and wheeled into place in wheelbarrows.

When the first half of the pavement was opened for travel it had a more severe test than it will ever have again, as the travel was confined to one track and the gravel for use on the other half of the pavement was hauled over it. Still it showed hardly any wear, notwithstanding the fact that it was only three weeks old. The length of the street paved was 3,495 ft., amounting to 25,781 sq. yds.

The total cost of the pavement, including all items, was $2.28, the original estimate having been $2.40 per sq. yd. The brand of cement used was Western States, costing about $2.40 per barrel. The cost of sand and gravel was $2 and $1.25 respectively, and for labor $2.50 per day of eight hours.

I wish to say that we are more than pleased with the pavement. It is not slippery and no more noisy than brick; it is easily cleaned by washing with a hose from the fire hydrants, and, with the concrete curbs and sidewalks, makes a fine looking street. One thing that helped the committee to decide in favor of concrete pavement was the fact that we had several concrete crosswalks constructed four or five years ago in practically the same manner as the pavement, and, as these showed little or no wear, the committee was of the opinion that the smooth pavement would not be submitted to the hard usage which a crosswalk, with soft mud on each side, might receive.

We know that there is nothing about this pavement to decay, and it will be as durable as the material put into it. I believe for the wearing surface great care should be taken to select hard, durable rock, and I believe the crushed rock is better than pea gravel. The sand should be carefully selected, hard and coarse, and enough cement used to thoroughly fill the voids.

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*Paper read at the Annual Convention of the Northwestern Cement Products Association at Minneapolis, Minn.

†City Engineer, Bozeman, Mont.

I am inclined to think that if the grooving run at angle of 45 degrees with the curb it might prevent the possibility of wearing into ruts which might be started by the grooves running parallel with the curb.

To insure a greater degree of uniformity in road maintenance and repairs, Mr. Frederick Gilkyson, Commissioner of Public Roads of New Jersey, has recommended that $6,000 be set aside each year for the employment and traveling expenses of two district supervisors, to be appointed by the Commissioner of Public Roads and to serve under him. These district supervisors should act under instructions from the Commissioner of Public Roads, have jurisdiction over all maintenance and repair work, advise with the county road supervisors and aid them in the prosecution of their work. The reason for this recommendation is obvious, since, with the rapidly increasing mileage of improved roads, it is impossible for the State Commissioner or the State Supervisor to keep constantly in touch with this branch of the work of their department. Mr. Gilkyson has also recommended that the State Road Law be amended to provide that after the first county road shall have been constructed under state aid, it shall be the duty of the board of chosen freeholders to appoint some suitable person as county engineer. In a number of the counties no provision has been made for such office, it being the practice of the board of chosen freeholders to secure the services of local engineers in making surveys, plans, profiles and cross sections necessary to be used in the construction of roads. As a result, there is a noticeable lack of uniformity in road building in such counties. In the counties having regularly appointed county engineers better results are obtained and the work is performed more economically.

The death is reported of Julius W. Schaub, who was born in St. Louis, Mo., Sept. 23, 1859. Mr. Schaub graduated from the Washington University in 1881 and was engaged from 1881 to 1886 with the late C. Shaler Smith. From 1887 to 1892 he was chief engineer of the Detroit Bridge & Iron Works, from 1893 to 1894, of the Pottsville Iron & Steel Co., Pottsville, Pa., and from 1895 to 1897, of the Hamilton Bridge Works, Hamilton, Canada. Since 1898 Mr. Schaub has practiced as Consulting Engineer in Chicago.

The Engineering Committee of the Sanitary District of Chicago has recommended the widening and improvement of the Chicago River between Adams and Van Buren Sts. and the construction of new bascule bridges at Adams St., Jackson Blvd. and Van Buren St., Chicago, at a cost of $2,000,000.

Unclassified and General Articles

Note: This section is devoted to methods and cost articles on construction work not properly coming under any of the preceding classifications.

Some Historical Notes on Piles.

Some bits of history, interesting at least as general information, are given regarding piles in the recent report of the committee of the American Railway Engineering and Maintenance of Way Association on Wooden Bridges and Trestles. We quote from the report as follows:

"Piles, or posts driven partly into the ground by blows of a hammer, are prehistoric in origin, and even the presumably later development of what are now termed 'foundation' and 'sheet piles' is too ancient to be a matter of record. The primitive pile driver was a large maul or beetle wielded by one or more men, the effectiveness of which was limited, since the weight and drop depended upon the reach and strength of the human arm. A heavier hammer raised by a pulley or roller supported at some distance above the pile head must have been the first great improvement in equipment. A number of men were thus able to use their strength, and by all letting go together the rope was drawn back by the descending hammer. The insertion of a releasing hook in the connection of the line to the hammer and winding spools or crabs permitted the use of heavier hammers, the more effective use of man's strength and the use of horses.

"The greatest impetus to the art was the introduction of the steam engine, which was probably first used * by John Rennie, 1801-1802, for driving the piles of the cofferdam of the Bell Dock entrance to the London Docks. The engine employed was of 8 hp. and was constructed by Messrs. Boulton & Watt. From this time on considerable attention was devoted to improvements in apparatus and new devices were employed more rapidly.

"In 1834 Alexander Mitchell, the inventor of the screw mooring, having made some experiments with screw piles, proposed their use for a lighthouse at the entrance to the River Avon. His suggestions and plans were not carried out, and it was not until 1838 that they were used on the Maplin Sand Lighthouse. These piles were of wrought iron, 5 ins. in diameter and 26 ft. long, with a 4 ft. cast iron screw of one and one-quarter revolutions, keyed on near the end. The projecting end of the pile was provided with a screw point, and the piles were screwed 16 ft. into the sand by handpower applied at a capstan head on a raft above.

"The steam hammer, patented in France by Francois Bourdon in 1841 and in England by James Nasmyth in 1842, was first used on a pile driver about 1845. This apparatus attained immediate approval and thereafter was in quite general use in England on works of magnitude.

"Labelye, in building the Westminster bridge in 1738, used an apparatus for cutting off piles under water. This was a wooden frame containing a crosscut saw and was moved backward and forward by men standing on the platform above. A much more complicated machine, invented by De Cessart in 1756, could be operated with great precision and was applicable to a greater depth of water.

"The earliest authenticated(*) use of the water jet in sinking piles appears to have been introduced on the construction of a wharf at Decrows Point, Matagorda Bay, Texas, in 1852, and to have arisen from a suggestion made by Lieut. Geo. B. McClellan, Corps of Engineers, U. S. A. The water was pumped by an ordinary hand pump through a rubber hose with a gas pipe nozzle, the nozzle being placed close to the point of the pile.

"In 1854 the foundation piles for the Pungateague Light, Chesapeake Bay, were driven by the aid of a water jet. These piles were hollow cast iron pipes with flaring bases, and the water from a hand force pump was carried through a 1-in. iron pipe inside of the pile.

"Unless the above piles, with their flaring or bell-mouthed ends, are considered as a modified disk pile, the earliest use of the disk type sunk by jetting seems to have been by James Brunlees in 1856, on the foundations of the Leven Viaduct, Morecambe Bay, England. Hollow cast iron pipes were used, 10 ins. in external diameter, bolted through outside flanges and having the base of the pile closed by a disk $2\frac{1}{2}$ ft. in diameter. Ribs or cutters were formed on the bottom of the disk and a 3-in. hole provided for the water jet. Water was forced through a 2 in. iron pipe, passing down inside the pile, from a pump driven by a donkey engine, and a rotary motion was given to the pile to bring the cutters into play.

"The first metal sheet piles were probably those used by Mathews in

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* "The Water Jet as an Aid to Engineering Construction," by L. Y. Schermerhorn, 1880.

*G. Rennie, discussion of James [illegible] paper, "Description of Piling Machine Used at Montrose Harbor Works."—Proc. Inst. C. E., Vol. 52 (1844).

England, about 1822, and in that year the first patent was granted to Ewart for a cast iron sheet pile of the ball and socket type. Subsequently other types were made of cast iron, but owing to the character of the material no very extended application occurred until, with the more widespread use of steel, various inventors turned their attention to the subject.

"The first rolled section of sheet piling patented in the United States was the ball and socket arrangement devised by Lewis Dodge in 1870. This was the forerunner of the 'United States' type patented by S. K. Behrend in 1899, and of the many subsequent varieties of interlocking rolled sections. In 1893 August Simon of Gnadau, Germany, patented the first of the built-up sections, which in a modification now known as the 'Jackson' type, was the first steel sheet piling driven in this country (Randolph Street Bridge, Chicago, in 1901). Further modifications of the built-up construction followed; i. e., the interlocking channel, 'Friestedt' type, in 1902, the beam clip 'Friestedt' type in 1903, and the succeeding modifications of various inventors."

LETTERS TO THE EDITORS.

A Bill Providing for the Creation of a Board of Examiners and the Examination and Licensing of Surveyor's and Civil Engineers in Washington.

Sirs: I enclose herwith copy of Senate Bill No. 279 and Substitute Bill No. 279. The original bill was drawn up by the Spokane contingent, who brought it down and had it introduced, and then abandoned it to its fate. As the bill as introduced provided that no non-resident could come into the state and practice unless he was a member of the American Society (this was probably an oversight on the part of the originators), and provided rather severe penalties, certain of us took it upon ourselves to remodel the bill slightly, and Substitute Bill 279 was the result.

This bill was introduced rather late in the session, and it was rather hard to obtain consideration for it. But as the President of the Senate and the Chairman of the committee were both engineers, the bill could have been passed had it not developed that the engineers of the state did not appear to want it. As time was very limited, the bill was submitted to leading members of the Engineering Society of the Pacific Northwest, and other engineers of the state. The Engineering Society of the Pacific Northwest declared against the bill, stating that the time was not ripe for such legislation. This action did not surprise me, as many of the members of that organization are leaders in their professoin, who would not look with favor upon legislation of this sort; but I was rather surprised to find that several engineers and surveyors, whom such legislation would undoubtedly help, were opposed to it. Still, there were several prominent engineers in favor of the bill, so it is still an open question as to how such a bill would have been considered, although I am of the opinion that a majority of the engineers and surveyors throughout the state would have been opposed to it, which opinion is based on the expressions of engineers consulted.

What really caused the bill to be permanently interred in the committee room was lack of interest. And with the engineers of the state either opposed to the bill or on the fence, no one cared to push it through. The Engineering Society of the P. N. W., while opposed to the bill, was of the opinion that in the near future such legislation would be necessary, and favored the drawing of a new bill two years from now, and submitting to the engineers of the state in time to get expressions from them in regard to the matter. In my opinion, such a bill will at that time be approved, and will undoubtedly become a law.

Yours sincerely,

G. L. H.

Olympia, Wash., March 19, 1909.

(The text of Substitute Bill 279 is given below.—Editors.)

SECTION 1. Within thirty days after the passage and approval of this act the governor shall appoint four qualified civil engineers, who, together with the state highway commission, shall constitute a state examining board for civil engineers and surveyors. The members first appointed under this act shall be divided into two classes, each class to consist of two. The first class shall hold office under said appointment for the period of two years, and the second class for four years from the date of their appointment. Every two years hereafter the governor shall appoint two qualified civil engineers to serve on this board for a term of four years and until their successors are appointed and qualified. A vacancy occurring in this board shall be filled by special appointment by the governor at any time to complete the unexpired term: *It is provided further*, That at all times, exclusive of the state highway commissioner, two members of this board shall be from that portion of the state lying west of the summit of the Cascade mountains and two from that portion lying east of the same. Before entering upon the duties of the board the members shall take oath to support the constitution of the state and of the United States and to perform their duties with justice and impartiality. While engaged in performing the duties of the board the compensation of said members, exclusive of the state highway commissioner, shall be $8 per day and necessary expenses, and the same shall be paid out of the fund hereinafter provided for. The state highway commissioner shall be the chairman of such board which shall hold meetings and examinations at such times and places as shall be designated by the state highway commissioner. There shall be at least two examinations held each year, one in the western part and one in the eastern part of the state.

SEC. 2. Every person desiring to become a licensed civil engineer or a licensed land surveyor in the state of Washington must present to the board of examiners a certificate stating his name, age, date and place of birth, his record of positions held or work done during the five years prior to his application, and extent of his education and the length of time of residence in the state, and in the United States if an alien, and whether or not he is a citizen of the United States. He shall name three references licensed in the branch he desires to enter with whom the board shall communicate. If the board is not satisfied with the credentials of the applicant they shall subject him to a thorough examination in such subjects and in such a manner as shall satisfy them as to his fitness or unfitness to hold the said license. An examination in surveyors' jurisprudence shall be required of every applicant for a license as surveyor. Upon the approval of the credentials by the board of examiners, the applicant for a license as land surveyor shall file his oath to support the constitution of the state and of the United States and faithfully to discharge the duties of a land surveyor, and shall file a good surety company bond in the sum of $500 for the faithful performance of his duty, and the said board shall issue to such applicant an annual license upon payment of a fee of $5.00. Upon the approval of the credentials by the board of examiners the applicant for a license as civil engineer shall file his oath faithfully to discharge the duties of a civil engineer and shall file a surety company bond in the sum of $1,000 for the faithful performance of said duties, and the board shall issue to such applicant an annual license upon payment of a fee of $5.00. All fees received by the board for licenses shall be paid into the fund hereinafter provided for. The license issued shall set forth the fact that the person is a surveyor or a civil engineer, or a civil engineer and surveyor, and authorized to practice as such within this state. All bonds herein provided for shall be to the state of Washington, and any person or persons who shall suffer any loss or damage by reason of any mistake or error of such surveyor or engineer shall have a right of action in his, or her or their own name on such bond for the full amount of such loss or damage. The first license issued to any surveyor or engineer shall expire on the 15th of January next succeeding the issuing of such license and thereafter a license shall be issued annually to such surveyor or engineer upon paying the license fee and executing the bond as provided in this section without the necessity of taking any further examination.

Sec. 3. All papers received by the board of examiners on application for licenses, including all examination papers, shall be kept on file in the office of the state highway commissioner and a proper index and record thereof shall be kept by him, and he shall keep a list of all licensed land surveyors and civil engineers.

Sec. 4. To be qualified to obtain a license as a land surveyor in this state the applicant must be a citizen of the United States and a resident of the state for one year, he shall have been in the active practice of surveying for three years. To be qualified to obtain a license as a civil engineer in this state the applicant must be a citizen of the United States and shall have been a resident of the state for one year, he shall have been in the active practice of civil engineering for five years, at least one of which he shall have been in responsible charge of engineering work. Graduation from a school of engineering of recognized standing shall be considered as equivalent to two years of active practice. A civil engineer may be granted a license as civil engineer and surveyor or if he has the proper qualifications for a surveyor as well as for a civil engineer as defined in this act, and if he files his oath as a land surveyor as provided for in section 2.

Sec. 5. Civil engineers, citizens of the United States, coming into the state shall receive a special permit to practice civil engineering upon the recommendation of three licensed civil engineers of this state, upon filing a good surety company bond in the sum of $1,000, payable to the state of Washington, and the payment of a fee (of) $10, which fee shall be turned into the fund hereinafter provided for. This permit shall be in force only to the end of the current calendar year, at the expiration of which, if residence in the state is not established, a new permit accompanied by the fee must be applied for, or if residence is established a license must be obtained.

Sec. 6. If an applicant fails to pass a satisfactory examination he shall be denied the privilege of taking a second examination within six months, and in no case shall he be granted a license upon recommendation and favorable references only after such failure to pass an examination given him by the board.

Sec. 7. Licenses issued in accordance with this act shall remain in force until revoked for cause or terminated as herein provided.

Sec. 8. Every licensed surveyor is authorized to administer and certify oaths when it becomes necessary to take testimony to identify or establish old or lost corners, or to perpetuate a corner that is in a perishable condition, or whenever the importance of the survey makes it desirable, and to administer oaths for the faithful performance of duty to assistants. A record of such oaths shall be kept as a part of the field notes of the survey. He shall comply with the United States regulations regarding the subdivision of public lands and the restoration of lost or obliterated corners, and he shall submit for record to the county engineer the field notes regarding such corners restored by him, within thirty days after making such survey, and it shall be the duty of said county engineer to record the same.

Sec. 9. Every licensed surveyor is hereby authorized to make surveys relating to the sale or sub-division of lands, the retracing or establishing of property or boundary lines, public roads, streets, alleys or trails, and it shall be the duty of each surveyor whenever making such survey, except those relating to the retracing or sub-division of town or cemetery lots, whether the survey be made for private persons, corporations, cities or counties, to set permanent and reliable monuments, and such monuments must be permanently marked.

Sec. 10. Every licensed civil engineer is hereby authorized to design, supervise and pass upon plans of engineering works.

Sec. 11. Unprofessional conduct, incompetency and non-compliance with the provisions of this act shall constitute grounds for the revocation of the license of a surveyor or civil engineer. The examining board shall hear the charges and the accused shall be given thirty days in which to answer the same. Upon due consideration of the testimony and the defense, the board shall decide the case and if the charges are proven they must revoke the license, and no license shall be issued to such surveyor or civil engineer within one year from the date of such revocation.

Sec. 12. The act of practicing the profession of land surveyor or civil engineer within this state after September 30, 1909 without first obtaining a license or special permit as provided for in this act shall be accounted a misdemeanor and shall be punished by a fine of not less than $25 nor more than $200, or by imprisonment of not less than seven days nor more than thirty days, or by both such fine and imprisonment. It shall be the duty of the prosecuting attorneys of the respective counties to prosecute all such cases complained of to them as contrary to this act.

Sec. 13. No survey of land or plat or sub-division shall be recorded after September 30, 1909, unless made under the direction of and certified to by a licensed land surveyor and no survey or plat for record of a railroad, highway, canal or irrigation ditch shall be recorded after said date unless executed under the direction of and certified to by a licensed civil engineer.

Sec. 14. All county engineers and all city engineers of cities of 20,000 inhabitants or more within the state shall be considered as licensed civil engineers until the termination of their respective terms of office. All city engineers of other cities and towns within the state shall be considered as licensed surveyors until the termination of their respective terms of office.

Sec. 15. Sufficient of the moneys received from license fees, examination fees and the renewal of licenses, under the provisions of this act shall be used by said board to defray the expenses of holding examinations in connection with the carrying out of the provisions of this act, including their own compensation and traveling expenses, and any surplus remaining shall be turned over to the state treasurer on the first day of January, 1910, and every year thereafter.

Sec. 16. All persons who are citizens of the United States residing in this state and who were engaged in the actual independent practice of land surveying or in the actual independent practice of civil engineering prior to the passage of this act shall be licensed without examination to continue such practice upon furnishing satisfactory proof of such citizenship and actual practice to the examining board within two months from the date of the passage of this act, accompanied by the fee and bond provided for in section 2 hereof.

Sec. 17. All surveys made under the authority of the state or any county, city, town or village within the state must be performed by a licensed surveyor. All engineering done under the authority of the state or any county or municipality within the state must be done under the direction of a licensed civil engineer or an engineer holding a special permit as provided for in section 5.

Method of Making a Rapid Preliminary Survey of a Drainage District.

Sirs: Being called upon recently to make a survey of a stream to determine the feasibility of adopting some plan to increase its flowage, and prevent its frequent overflows with consequent loss of crops along its course, I thought perhaps the manner of conducting the survey might interest some of your readers and be of service in helping others to conceive a better plan [illegible].

The work was undertaken in the winter and a part of the time the weather was very disagreeable, the instrument often suffered from cold, and numb fingers sometimes rendered it almost impossible to write the notes required. On two days the fog was very heavy during a part of the day and the work did not begin until nearly noon and then was hindered by the necessity of taking short sights.

The work was done for a group of farmers who paid the costs and desired the information to use in court, in their effort to secure the establishment of a drainage district, to cover a territory of about 40 square miles. They furnished the chainmen and all other help, and the instrument man lodged with the nearest at the close of each day's work. By liberal use of a rural telephone line arrangements were made each night for the helpers for the next day, but it was always the aim to keep the same rod-man as long as possible.

The instrumnt used was a light transit, with level under telescope, and was in excellent adjustment, and had been proven to be a very reliable instrument, and was chosen for the facility with which it could be handled in the brush and weeds which abounded along the line.

The work was begun at the upper end of the district to be surveyed and followed the meanderings of the stream to its confluence with the Arkansas River, a distance of 19.4 miles.

At all farm boundaries and other points where convenient, the water level was taken, and at all other stations the elevation was taken, so that when the notes were worked up we had all the data necessary to show the profile of the route traversed, and the fall of the channel from point to point throughout its course, also the points where improvements in alignment would be most effective.

Notes were made also of serious obstructions in the way of drift accumulations, and all other conditions necessary to a thorough understanding of the conditions along its course.

At several points along the creek individual farmers had taken some steps to straighten the channel, etc., and all these were also noted.

Some one fully familiar with the section to be worked each day was secured to go ahead each day and choose station points. Of course they were fully instructed as to the points to bear in mind in making these selections and after a little experience rarely chose a point that for any reason had to be abandoned. They were closely followed by the axemen, who removed all obstructions to the line of sight.

The point chosen and the line cleared the rodman set up the target rod, no ranging poles being used, the rod serving this purpose, the instrument was trained on the rod and the direction noted. The rodman was signaled for the target adjustment, and as soon as this was secured the instrument man went rapidly forward and set up the instrument for a new sight, only a few feet from the rod. He then noted the target reading, the inexperienced rodman not being trusted to do this, and trained the glass on the rod for a backsight, which was noted, and the rodman hurried forward to the new station that was already selected, and the line thereto cleared. In setting the transit for the backsights a point was always chosen directly in line with the rod and the next station, or with the rod between them, as it was not considered necessary to secure that degree of accuracy to be sought in location work, or on lines for construction work where such survey was to be the basis for future contracts.

The chainmen gave the distance which was noted by the transit man, and they too went forward toward the new station point.

This was the method adopted at the beginning and it was not found necessary to make any changes during the progress of the work.

When the chainmen reached the new station the head man noted the distance, so that it would not be forgotten before the transit man reached them, and at once took the distance to the water's edge from the station point. All boundary lines and points of serious overflow were noted, and in fact the transit man kept "all eyes open," that no feature of interest in the case should be allowed to escape the note book.

There were 360 stations in the survey, and despite the amount of notation made, and difficulties under which the work was done, the courses totaling a distance of 19.4 miles were run in six and one-half short winter days.

The work was then platted in the office to a scale of 300 feet to the inch on tracing cloth, and a full typewritten report of the findings of the engineer prepared for the committee of farmers having the matter in charge.

About this time the law under which the work was sought to be done was declared unconstitutional by the judge of a district court, and until the legislature remedies its weak points no work can be done in this state along the drainage district line. In the meantime in some localities the surface water troubles are growing to a very serious proportion with no prospect of relief.

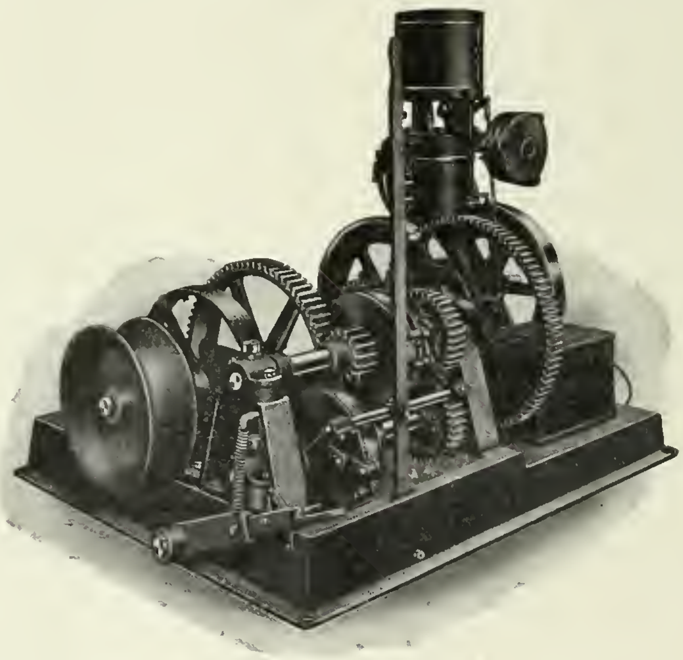
Yours truly,

O. T. Reece.

Wellington, Kansas, March 23, 1909.

An Improved Contractors' Hoist.

The accompanying illustration shows a contractor's hoist that has a number of points of merit. This hoist is operated either direct connected or by chain drive by gasoline engine and with power for elevating from 400 lbs. to 2,000 lbs. As will be seen, the whole mechanism is mounted on a one-piece base casting. Without power attachment it weighs 825 lbs. The engine runs one way all the time, the direction of the load being reversed by means of friction clutches operated by hand lever and reversing the rotation of the driving sheave at will. It will be noted that there are few gears and that they are so placed as to reduce friction to the minimum. A point is made by the makers of this arrangement of gears and particular economy of operation is claimed because of it. The hoist operates two cages simultaneously, one going up as the other descends. This hoist is manufactured by the Holton & Weatherwax Co., Ltd., of Jackson, Mich., and is known as the "Advance" hoist.



Advance Hoist for Building Contractors.

Building activity for February in 95 larger cities, as measured by the value of permits granted by municipal authorities, shows an improvement not only over the abnormally low February, 1908, figures, but also over the totals of the preceding months. The February total of the value of permits granted was $56,330,324, as against $48,707,054 for January.

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Announcement of First Meeting of the American Society of Engineering Contractors.

As previously stated, Mr. Gillette has received nearly 1,500 applications for membership in the American Society of Engineering Contractors. The time, therefore, is ripe for perfecting the organization of this body of contractors and engineers into a national society. Arrangements have been made to hold the first meeting in the United Engineering Building, 25 West 39th street, New York City, April 14 and 15. The session will begin at 1 p. m., April 14, when committees will be selected to draft a constitution and by-laws.

We have commented upon the purposes of this society with such frequency that it is scarcely necessary now to do more than to refer our new readers to the membership application blank which will be found on one of our advertising pages. On that blank will be found an outline of some of the things that the society will undertake to accomplish.

Have Cost Data Little Value to Others Than Those Who Have Gathered Them?

This question is again raised in a paper on "A System of Cost Keeping," by Myron S. Falk, printed in the March Proceedings of the American Society of Civil Engineers. Mr. Falk says:

"The description of itemized costs of contract work always attracts some attention, unfortunately, the greatest amount of publicity has been given to the actual costs of unit items on construction work rather than to the bookkeeping methods used in obtaining those quantities. It seems hardly necessary to call attention to the very small value that cost records may have to others than to those who gathered them and who realized and understood fully every local condition at the point of construction. There are some, however, who believe that all cost records have value, and that their publication, no matter in what form, will be a benefit. There is no doubt that the records of cost of completed work are useful to some slight extent to others than their compilers, but the greatest value of such records is derived during their collection by the men who are doing the work.

For the benefit of the new subscribers to this journal, it may be well to state that this controversy over the value of cost data was started about a year ago at the conclusion of the investigation of the award of the Ashokan Reservoir to a contractor who was not the lowest bidder (see ENGINEERING-CONTRACTING, Feb. 12 and 19, 1908).

The engineers for the reservoir and certain consulting engineers held that the lowest bidder had bid a losing price. A commission of four engineers, among whom were two of the editors of ENGINEERING-CONTRACTING, were appointed to investigate the matter, and held that the lowest bid on the Ashokan Dam should have been accepted. Subsequently three more engineers were called in and concurred in the opinion that the lowest bid was a profitable bid.

In the effort to support the wisdom of the award of the Ashokan contract an attack was made upon "published cost data," although, in truth, published cost data were not on trial at all. However, both in the hearings of the case and subsequently in certain technical publications, an attempt was made to belittle the value of published cost data, the idea apparently being that by so doing the report of a commission of engineers who believed in the value of published cost data would be given the brand of "theoretical conclusions." We need not dwell upon the fact that the commission of nine engineers was selected because of their first hand knowledge of actual costs, and that they used published cost data merely to corroborate their own personal experience. So much for the inception of this controversy over the value of published cost data.

Mr. Falk allies himself with the "old school," and, while admitting that published cost data have some value, undertakes to belittle the usefulness of published records of this sort. We all concede that bare figures of cost may be almost worthless to anyone except the person who gathered them, but this is not the question at issue. It is equally true that bare data as to the strength of steel are almost worthless. The chemical composition of the steel, the method of manufacture, the size of the test piece, and other factors are highly important accessories that should accompany the tabulated records of strength. No engineer ridicules strength data in general because of the incompleteness of certain information in published strength records. His ridicule is directed rather at the incompleteness of the information furnished. Yet we find certain engineers and certain editors of engineering periodicals taking the illogical position that there is something unique about cost data which makes them almost wholly useless, whereas all other data are of very great value.

We are told that methods of construction should be described for the guidance of other men, but in the same breath we are informed that cost—the only possible criterion of the efficiency of a machine or method—should be religiously excluded from the published description because they may, forsooth, become misinterpreted [illegible].

Faced with such a [illegible], the defender of [illegible] of costs will reply that he would probably favor the publication of cost data were it always possible to secure as complete a

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picture of local conditons as is recorded in the brain of the man who has compiled the data. Is there something so vague and intangible about local conditions that they can never be reduced to a written form intelligible to those who have not been on the spot? Scarcely, for every description of a method is merely a description of these very sorts of things. Hence, if it is held that local conditons, including plant arrangement and organization of working forces, can not be adequately described in print, printing of methods might as well cease as well as printing of costs, thus wiping out all engineering literature except applied mathematics.

It is noticeable that the opponents of published cost data are representatives of the old school of engineers who revere the name of Rankine and revile everyone who attempts to "commercialize engineering." The late A. M. Wellington was one of the earliest American engineers to face the fire of such criticism, because he had the audacity to maintain that there could be a real theory (= science) of economic railway location. The engineers of the old school took the position that about all there was of science in railway location was to be found in a field book of curves—the rest was "art." No one holds that position today. There are "economic theories" of railway location used by every experienced railway engineer.

We may set it down as an axiom that whatever can be viewed with the human eye and tested with instruments can be described and illustrated so as to convey an accurate idea of its characteristics to any one who has seen similar things. To the man who has never seen anything analogous to the thing described, it is true that descriptions are likely to be deceptive. Conceding this axiom it follows that it is possible so to describe and illustrate the conditions of all but invisible work (such as the lower strata of ground encountered by piles, and the like) that a man of moderate experience can form almost as clear a mental picture as the man who has seen the work. All well written articles on methods of construction aim at this ideal, and many attain it. When such well written articles on methods are accompanied by detailed unit costs, the ideal engineering article is produced, for then the critera of efficiency are laid before the reader in such a manner that he may judge whether the methods used are better or worse than he himself employs, and therefore worthy of being adopted or not.

A few years hence, when engineers and contractors have before them an even greater volume of methods and cost matter than is now available, we shall look back on the present controversy over the value of published cost data as we now look back upon the early arguments over the truth and value of the Darwinian theory of evolution.

The News Value of Our Advertising Pages.

Not every reader—nor, indeed, every advertiser—realizes the fact that our advertising pages are news pages. This present issue of Engineering-Contracting is particularly rich in advertising news matter, but hardly an issue appears that does not contain illustrations and descriptions of several new machines, or new methods of using old machines, in the form of advertisements. This must necessarily be so, for there are some 3,000 manufacturing firms producing machines or supplies used by engineers and contractors. It is manifestly impossible to describe all the new or improved machines in our reading pages even once. Yet one description is usually inadequate, and manufacturers are perceiving the advantage of being able to describe their products in serial advertisements, using their own language and arguments. In brief, the advertising pages are steadily becoming more interesting. They have long ago ceased to be a mere directory, and are rapidly undergoing an evolution that promises to result in their being read every week with as much interest as attaches to the articles.

To illustrate our point, turn to advertising page . . no, on second thought we will leave it to the reader to decide for himself which particular advertisement is entitled to the special mention that we were about to give it.

A point that we wish to emphasize again—we have mentioned it before in these columns—is the fact that without the support of its advertisers every engineering periodical would either be forced to cut down both the quantity and quality of its reading matter, or add very materially to its subscription price. Clearly, then, the existence of advertising pages is of great indirect value to the readers, aside from the direct value of furnishing valuable information about products. Therefore there is more than mere courtesy involved in "mentioning this paper" when writing for a catalog or a quotation. The mention of the paper in which the advertisement was seen by a reader is the best evidence that the advertiser has that it pays to advertise. Encouraged by the success of his advertising, the advertiser continues to patronize certain papers, and those papers, in turn, are encouraged to secure a larger quantity of good reading matter for their readers.

It is not the policy of many journals to speak thus frankly of their indebtedness both to their readers and to their advertisers for their success. They assume, rather, that any success is inherent in themselves. Only in a measure is this so, for the journal is merely one of the three legs of the tripod, not one of which can be removed without the fall of the other two.

Engineering-Contracting feels that its steady and surprisingly great growth is due to a loyal band of advertisers, whose loyalty, in turn, may be traced to the interest that its readers have shown in its advertising pages. Its old advertisers have continued their support, and new advertisers have been attracted by this stability, until the present issue contains almost twice as many pages of advertising as were carried in the corresponding issue a year ago.

Depositing Concrete Through Chutes.

Many engineers regard depositing concrete through chutes as a practice to be distrusted. We consider this attitude unfortunate. There are frequent occasions when chuting is the most direct and economic method of getting concrete into place. On such occasions it should be permissible unless there is some insuperable objection, due to other reasons. Is there such an objection and what is it? So far as we know the only objection urged against chuting is that it segregates the concrete—separates the stone from the finer material. How great reason is there for this belief? If there be any, is it not practicable to obviate the fault? We believe that segregation can be avoided in depositing concrete through chutes and, this being so, that chuting is a wholly reliable and economic method of depositing concrete and should be employed wherever convenience and cheapness dictate its use.

In subaqueous concreting special forms of chutes called tremies are frequently used. As long ago as 1874 General Gillmore described the use of a tremie for subaqueous concreting in Chesapeake Bay, and the device is probably of prior origin. Experience with tremies for work under water will be found stated in several of the general treastises on concrete work and particularly in "Concrete Construction, Methods and Cost" by Gillette and Hill The tremie is a special construction of chute in respect that it is a closed tube, and it serves a special purpose, which is to keep the concrete from being washed while being deposited, that the ordinary chute is not called upon to serve. This is the reason for the closed or tube-like form adopted. We have no records of resulting segregation with a tremie properly handled. This may be due to the fact that the tremie is operated as a pipe flowing full and continuously, a procedure dictated also by the purpose of excluding water from contact with the concrete during deposition, but if it is, it at least indicates one way of avoiding segregation in chuting concrete.

Closed chutes operated like tremies, that is, kept flowing full, have been successfully employed for depositing concrete in air. In one instance noted by the present writer some 16 years ago the vertical travel of the concrete in the chute was about 20 ft. and the result was wholly satisfactory. Indeed the engineer in charge of the work, a man experienced in concrete work, stated that he wouldn't hesitate to approve the same method for a drop of 100 ft. if the occasion should arise for such action. In-a few cases similar closed chutes have been used in filling with concrete the wells or open circular caissons so generally employed in building foundation work in Chicago. These caissons vary in diameter from 3 ft. to 12 ft. and in depth from 90 to 110 ft. and they are simply circular wells curbed with wood staves and filled with concrete. In using closed chutes for concreting these caissons the method is not to have the chute flow full, as above described, but to dump the concrete into it, a carload at a time, and let it fall free to the bottom. The closed chute, therefore, performs little other service than to confine the concrete during its fall and prevent scattering. It may be mentioned here also, apropos of the permissibility of depositing concrete by a free drop, that in a large proportion and perhaps most of this Chicago foundation work the concrete is simply dumped into the top of the caisson and let fall to the bottom with no tamping or spreading. This method does not seem to have been injurious, for in the several instances in which these concrete piers have been laid bare after construction the concrete was found to be remarkably solid and uniform.

Passing to the use of open chutes or troughs we can find numerous examples of their successful use for depositing concrete. In 1902 Mr. W. J. Douglas used an open trough chute on an inclination of 45° and having a vertical drop of 60 ft. This chute was simply a rectangular trough, and it discharged at the bottom into a hopper from which wheel-barrows were filled. This chute took the concrete from a continuous mixer, and it was found best to let a quantity of concrete accumulate behind a gate at the top of the chute and to drop it down the chute in a mass by throwing open the gate. The reason for this can be readily understood when we remember the thin stream of the discharge from a continuous mixer. With mixers which discharge the whole batch at once there would be no necessity for the top gate. Though this chute did not deposit the concrete directly in place, there was no reason, so far as segregation or other conditions of the concrete, why it should not have done so had it been expedient.

Among recent examples of depositing by chuting we may mention reinforced concrete arches at Cleveland, O., and Bethlehem, Pa., a filter plant at Pottstown, Pa., and several reinforced concrete buildings on the Pacific coast. In regard to this reinforced concrete building work we were recently informed in a brief conversation with a contractor who had witnessed the method that it seemed destined because of its success to wide adoption. Information of somewhat more specific nature is given in a description of an office and theatre building recently made public by the engineers who designed and supervised the reinforced concrete work. We quote their statement as follows:

"In a convenient place a tower was erected up one side of which the hoist track was placed and on a platform some 20 ft. above the work on the building was a hopper, with a capacity of two or three batches of concrete. This tower track and hopper were elevated as the work progressed story by story. From the hopper, controlled by a gate, the concrete was run into a 7 in. galvanized iron pipe of movable sections and one or more ball bearing joints, and delivered on the work where desired. Some difficulty was experienced at first by having either too small or too large a pipe, but it was found that a 7 in. pipe was about right, and by running a little water in the pipe before starting and afterwards to clean it out, little or no trouble was had. This gravity system was very satisfactory both to the contractor by reducing the labor force and to the engineers in charge, by doing away with the running over the form work and newly deposited concrete by a large force of laborers. It also gave a concrete of very uniform consistency in that if too dry it would choke up the pipe and if too wet the aggregate would separate. Properly handled it is very satisfactory."

The contractors of the Bethlehem, Pa., bridge, mentioned above, deposited some 5,000 cu. yds. of concrete by means of steel lined chutes and through a maximum vertical distance of some 71 ft. They report no trouble from segregation and that the concrete was uniformly good. In the Cleveland bridge work also mentioned above a similar report of highly satisfactory results is had.

These examples might be increased in number by a little search, but they are sufficient to demonstrate the feasibility of depositing concrete for even high class reinforced work by means of chutes. Certain precautions must perhaps be taken to insure the best results, but they are of a simple nature. The consistency of the mixture is perhaps the most important problem.

A wet concrete will flow quite readily on a slope of 1 in 4. In constructing the reinforced concrete aqueduct for the Jersey City, N. J., water supply, Mr. Wm. B. Fuller deposited concrete through short chutes having a slope of 1 in 8. The travel of the concrete was short and a special mixture was used. The concrete was made of graded aggregates and was mixed wet and mushy, but without any quantity of free water, and both these facts doubtless aided in the success of the chuting. A graded concrete works better something as a fat mortar works better, that is, it flows and spreads smoother. Also a concrete which is wet and mushy without being sloppy holds together better as it flows, an excess of water giving a considerable amount of free liquid is bound to separate and carry much of the fine material down the chute ahead of the stone.

In chuting concrete a mixture is wanted which is just as wet as it may be and "hold together" well when flowing. A rich mixture flows better than a lean mixture, and a mixture which has been thoroughly worked in the mixer flows better than one which has not. The contractor can determine the wetness of mixture which flows best by making a few trials with mixtures of different consistency.

A slope of 1 in 8 is about as flat probably as concrete will flow on without help even when the travel is short. We have one record of concrete being conveyed some 200 ft. in a V shaped chute having a slope of 1 in 10, but men with paddles were stationed at intervals along the chute to "paddle" the stream along. Obviously the inside of the chute, particularly if its slope is flat, should be as smooth as practicable. A lining of sheet iron helps in this respect, and is also more easily cleaned. Cleaning is essential at the end of the day's work and in beginning work again trouble will be avoided in handling the first few batches if the inside of the chute is previously well drenched with water to lubricate it.

The construction of chutes does not admit of carelessness. The loads they have to handle, particularly on steep inclinations and with large batches are considerable. They must have ample strength against bending or sagging between supports; if the supports are far apart the chute will need to be stiffened by truss rods or some similar simple means. If the chute changes direction, say, from a 45° slope to a vertical drop into the forms, the elbow connection needs to be firmly anchored against the shock of the flowing mass due to its change of direction. If the chute has a long steep straight run, some arrangement is desirable to prevent scattering when the stream discharges. A canvas sleeve depending from the chute or a short vertical elbow will commonly accomplish the result. The time for which chutes will be used is ordinarily not long enough to demand much attention to the question of wear, but the wear from fast moving batches of concrete is considerable and where a chute will have long use provision must be made for wear. In constructing the Cascade Locks where the work extended over several years and a rather expensive traveling steel chute was used throughout it was found economical to line it inside with a removable steel lining to take the wear. This lining needed to be removed several times during the work.

These comments on depositing concrete through chutes have grown somewhat discursive, but they may not be entirely useless for that reason in strengthening the contention with which we started that chuting is a convenient and safe practice and should be recognized as such. When time can be saved or work cheapened by using chutes instead of other common methods there is, in our opinion, no reason why, if ordinary care is used, they should not be employed.

Concrete and Reinforced Concrete Section

Note:—This section is devoted to methods and cost of constructing concrete and reinforced concrete structures. It will cover the selection, testing and proportioning of concrete materials; laboratory tests of concrete; concrete mixing, transportation and placing; fabrication and placing of reinforcement, and form construction and erection. It will also contain articles on new and interesting developments in the design of reinforced concrete.

Method of Constructing an Eight Story Reinforced Concrete Building with Some Data on Costs.

The building was an office building constructed for J. P. Baxter at Portland, Me., and the conditions were unusual, involving in particular very rapid work by the contractor. The foundations for an 80x175-ft. building had already been put in, but no decision had been reached as to whether the building would be utilized for hotel or office purposes, nor what its height should be. It was then late in August, 1908. After inspection of the work done it was decided to build a six-story superstructure and to employ reinforced concrete in connection with a special design to insure economy. The entire matter of design and erection was placed in the hands of the Aberthaw Co., Boston, Mass., under a special form of agreement. A fundamental condition was that $2,000 should be forfeited if the concrete work of the roof was not in place by December 1st provided that the foundations were turned over on September 1st: the latter was not actually done until a few days after Sept. 1. In the meantime the height was changed to eight stories.

Work was actually started on the superstructure about the middle of September, on Dec. 1 the roof was in place and the side walls were half way up on three sides and the front brick work had been begun. Two stories were put on in eleven days.

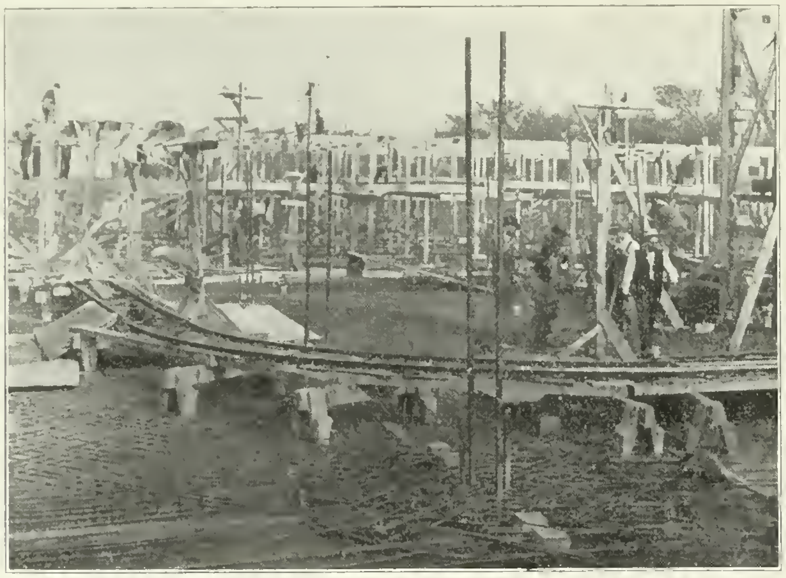

Fig. 1—View Showing Reinforcement and Track for Concrete Cars.

The construction decided upon was concrete columns and flat slab floor construction. Brick walls 12 ins. thick rest along the concrete beam which runs between columns at the outer edge of the floors. This wall rests 8 ins. on the concrete beam and extends 4 ins. outside, thus giving a 4-in. veneer over the concrete beams. This is the same construction as is used with a steel frame and gives the appearance of ordinary brick wall construction. The lower floor was figured for store loads and the upper floors for the usual office loads.

The columns were molded of unusually rich concrete, 1 part cement, ½ part sand, and 2 parts of crushed stone. Embedded in the columns are vertical steel bars. The ends of these are milled so as to give an even bearing from one to the other. Around these are steel hoops, and on the lower floors there is a large cross section of steel beside the concrete carrying the load. The tops of the columns flare and steel bars which extend down the column inside the steel hoops branch off from the columns and are joined together by horizontal hoops at the floor level. When the concrete is in place, it will be seen that the arrangement of steel acts like a spread footing built upside down, and over these heads steel bars run three ways so that every part of the floor slab has a mat of steel at the bottom carrying the weight to the columns. The construction is quite clearly shown by the view, Fig. 1.

The floor slabs are 7 ins. thick for the first floor, and 6 ins. thick for the floors above. During the construction when the floors were green, brick were several times piled 4 ft. deep over different bays. Plaster was applied directly to the under side of these floors. This does away with lathing, and as there are no beams it saves in the total height of the building. For finish floors, screeds bedded in cinder concrete rest on the floor slabs and across these are nailed the finish floor. The electric light ducts and plumbing run under this wooden floor. There will be two electric passenger elevators and a freight elevator with a separate entrance in the rear.

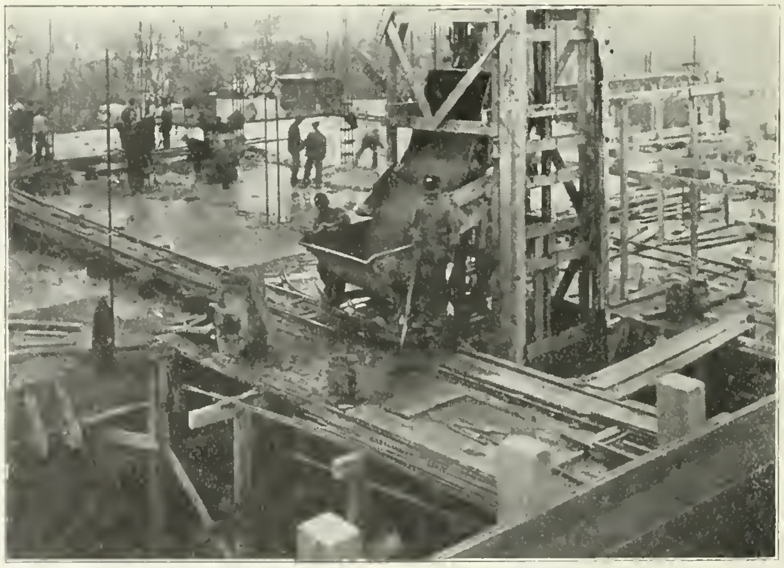

Fig. 2—View Showing Top of Concrete Hoist and Car Track.

In the basement was set up an electric motor driving a counter-shaft which in turn drove the mixer, the hoist, and some other light machinery for sharpening tools, etc. A hole was left through the first floor of the building over the mouth of the mixer and a hopper was built on a level with the mouth of the ... over the bucket of the mixer. Sand, stone and cement were stored on the first floor, the stone and sand in piles from which they were measured into front dump cars and discharged into the hopper. Into the hopper was also dumped the cement and a valve discharged this into the mixer. Water was taken from a barrel hung on trunnions and tipped into hopper. An automatic dumping bucket operated on an elevator tower dropped into the hole in front of the hatch of the mixer so that the mixer would discharge into it. Concrete was dumped by the bucket into a chute which discharged it into a side dump car (Fig. 2). This car ran on a similar track set up to proper height from the centering of any floor, and from the car it was dumped directly onto the floor and very approximately into its final position. By this method the concrete was not touched by hand except in loading the sand and gravel cars and what little shoveling was necessary after it was dumped on to the forms. The concrete was mixed very wet and all stone passed a 1½ in. hole in rotary screen at the crusher.

As far as possible all forms were cleated together and very little lumber was used outside the cleats. The forms from one floor were moved to a corresponding position in floors above, the different cleated sections being numbered for the purpose of identification. Electric lights were strung over the job so as to allow night work. It was customary to do concreting by daylight when it was possible to see very clearly everything relating to reinforcement and to permanent construction. As far as possible the night work was confined to the placing of steel reinforcement and the handling of forms.

The organization consisted of a superintendent, boss carpenter, competent foreman for placing the reinforcement, and labor boss, along with timekeepers and material clerk, and later on, brick boss, man in charge of carpentry, and the usual line of gang bosses. As usual on all work done by the Aberthaw Company the reports were made out daily showing the number of hours employed on each different kind of work and the number of units of work accomplished so that at the end of the day it was possible to tell the exact labor cost of each kind of work. The cost of placing steel reinforcement divided by the number of tons gave the cost for that day of the handling of the reinforcing metal. The same procedure divided by the square feet of forms placed would give this cost. All material entering into the work was also reported. This feature is valuable in contract work in judging the efficiency.

From these records the following costs of work were obtained:

The cost of forms including bracing and scaffolding was per square foot of concrete surface in contact with forms as follows:

Item	Columns cts. per sq. ft.	Floor slabs cts. per sq. ft.
Carpenter work	[illegible]	[illegible]
Lumber	[illegible]	[illegible]
Nails and wire	[illegible]	[illegible]
Totals	[illegible]	[illegible]

The cost of the concrete in place was as follows:

Item	Columns cts. per cu. ft.	Floor Slabs cts. per cu. ft.
Cement	[illegible]	[illegible]
Aggregate	[illegible]	[illegible]
Concrete labor	[illegible]	[illegible]
Cement labor	[illegible]	[illegible]
Team and misc.	1	1
Plant	[illegible]	[illegible]
Totals	27.3	[illegible]

This gives a cost per cubic yard for materials and mixing and placing concrete of $7.37 for columns and of $6.80 for floor slabs.

There were 321½ tons of reinforcing steel used in the building and it cost to shape and place $5,115 or $15.76 per ton.

Unit Costs of Reinforced Concrete Building Construction.

BY T. HERBERT FILES.*

This article will deal with a few costs, with which the writer has come in contact in reinforced concrete construction. The costs here given are those of labor only, as labor costs are usually the unknown ones in estimating, the material costs being easily obtained from the schedule of quantities and the market prices.

These costs are taken from different work which the writer has been on and are known to be correct for that kind of work. They are not obtained from rough figures after the work was finished, but from carefully kept cost records. All of the costs are from jobs consisting of a number of buildings.

The cost analysis was kept in the following manner: Each job had a cost keeper whose only duties were those of keeping the average weekly cost of the different work of construction. The distribution of the time was taken either from foreman's reports or from time cards. Most of the costs given in this article are obtained by means of time cards.

Time cards are rather difficult to get from the ordinary labor employed on construction work, but this difficulty was overcome by giving the foreman of the labor gang enough time cards for each man in his crew. The carpenters and better class of laborers made out their own cards. Each man had to pass in a time card as he checked out at the timekeeper's window at night. In this way the record of each man's time and work as was given was passed into the office each night and no special time was lost as usually happened when the distribution is taken from foreman's card.

The cost keeper would go over these cards the next day and enter the total of the labor on each class of work on the cost keeping sheets. The record was divided into different accounts, one for each division of the work, such as excavation, concreting, forms, floor finish, steel, etc. All time was charged against its proper account in such a way as to show the date, kind of work, total time, and wage rate as shown by the accompanying form.

The total number of hours in the analysis was checked up each day with the total number of hours on the timekeeper's sheets. At the end of each week the total cost of each kind of work for the week and the unit cost were figured up and a summary made of the totals of the different accounts. This total was then compared with the pay roll. If everything has been carried through correctly, the two totals should check within a few dollars. They will not check exactly, as average wage rates are used in the cost keeping. As cost figures do not mean much unless the rates of wages are known, the average rates paid will be given. They are as follows:

Date	Kind of Work	Hrs.	*Rate	Unit Cost	Total Cost

Common labor as used in excavation, unloading materials and unskilled work, 17½ cts. per hour, foreman, 30 cts.; concrete labor, 19 cts. per hour, foreman, 30 cts.; steel labor, 25 cts. per hour, foreman, 30 cts.; form labor used for stripping and rough carpenter work, 30 cts.; carpenters, 31 cts. per hour, and foreman, 50 cts.

Costs of Unloading Materials. Cement is usually unloaded by laborers carrying the bags on their shoulders from the car or by wheeling in wheelbarrows. If a car can be unloaded direct from the car into the storage shed with very little carrying, six men can unload 600 bags equivalent to 150 bbls. in 3 hours at a unit cost of 2 cts. per bbl. If unloaded by wheelbarrows with a distance of 100 ft., it will cost 4 cts. per bbl. but may run up to 5 cts. or 6 cts. if the men are not handled in the proper manner.

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*161 North 5th St., Allentown, Pa.

Sand and gravel will cost on an average of 8 cts. per cu. yd. for unloading, laborers shoveling it from the car to the storage pile nearby. The cost varies from 6 to 10 cts., depending upon conditions.

Reinforcing steel bars can be unloaded at a cost varying from 35 cts to $3.00 per ton, depending upon the carrying distance. Here are some actual costs:

Unloading ¾ in. x 20 ft. twisted steel, from box cars and piling it on ground beside car 32 cts. per ton.

Unloading from gondola cars, carrying 300 ft. and piling on racks in steel shed, $3.00 per ton.

The unloading of lumber differs considerably in cost, same depending upon the distance carried and the size of the sticks. It was found however, from our records that it cost from 70 cts. to $1.00 per 1,000 ft. B. M. to unload, haul 200 ft. and pile, form sheathing.

Form Work.—The cost of form work is the most difficult cost to get in reinforced concrete construction. This is especially so in regard to the making of forms, as the work on construction jobs is usually done in such a manner that it is hard to distribute the costs properly and have the correct amount of work done, reported. The cost work here referred to was not started in the best way to give good costs of the making of forms and for that reason the costs of making forms will not be as complete as might be. The unit costs were figured on the number of square feet of form surface in contact with the concrete.

The following are some of the costs of forms made in a field carpenter shop, which consisted of two saw machines, a planing and a boring machine, with a shop foreman in charge.

	Per. Sq. Ft. of Surface.
Columns	cts.
Girders and beams	5 cts.
Floor panels	2 cts.
Wall panels	3 cts.

The cost of setting forms for the floors, which included time spent in the moving of the forms from one floor to another, erecting and setting the forms of columns, beams, and floor panels and the falsework supportnig them, was figured per sq. ft. of floor surface. The costs of different floor set-ups varied, because the men at first were unskilled and not well organized. From 1,300 to 1,800 sq. ft. of floor were set up in a day. These costs ranged from 13 cts. per sq. ft. for the first set-up to 4.7 cts. for the roof set-up, making an average of 8.4 cts. per sq. ft.

The stripping of the floor forms cost from 2.5 cts. to 1.5 cts. per sq. ft., or an average of 1.9 cts. per sq. ft. of floor. This makes the cost of setting up and stripping of forms for floors average 10.3 cts. per sq. ft. of floor.

The curtain walls, between columns, were put in place after the floors and cost from 6 to 10 cts. per sq. ft. of form surface for setting up, or an average of 8 cts. The cost of stripping these was ½ ct. per sq. ft. Partition walls and outside plain walls cost from 4 to 8 cts. per sq. ft. of form surface or an average of 5 cts. for setting and ½ ct. per sq. ft. for stripping.

Reinforcing Steel.—The steel used for reinforcing was twisted rods. The column cages, beam and girder reinforcements were made up into units in the steel yard. From there they were carried and hoisted to the different floors, as they were made ready for concreting, and were put in place by the steel gang before concreting. The floor steel was placed as the floor was concreted.

The cost of the steel work is divided as follows:

	Per Ton.
Unloading	$2.00
Making up steel	5.50
Carrying	1.75
Placing	1.00
Total	$10.25

Concreting.—The labor costs in concreting vary a great deal with the plant and method of conveying. On this work, the concrete was machine mixed, the materials being run into storage hoppers over the mixer, by a self dumping car, on an inclined track, from the material pile, where it was loaded by hand. The concrete after being mixed, was raised to the proper floor by a hoist, which dumped automatically into a hopper. From this hopper the concrete was wheeled to the desired location by means of concrete carts. The greatest wheeling distance was 350 ft. and the least 50 ft., making the average distance 200 ft. The costs of concreting columns and floors ranged from 2.8 cts. to 4.2 cts. per cu. ft., or an average cost of 3.5 cts. per cu. ft.

In concreting footings, the material was moved to the mixer by means of wheelbarrows instead of self dumping cars, and wheeled to the desired location over plank runs. Under these conditions the cost of concreting was 5 cts., with the carrying distance the same as for the floors.

The record for daily excavation in the Central Division of the Isthmian Canal was broken on February 27, 1909, for the fifth time during the month. On that date 59 shovels excavated 77,064 cu. yds., an average of 1,306 cu. yds. per shovel for the 8-hour day. The material excavated was loaded in 2,177 Lidgerwood flats, 352 large Western dump cars and 2,754 small Western and Oliver dump cars, a total of 5,283 car loads.

Hints to Inspectors of Concrete Work.

II.

Form Work.

Forms are the molds in which the concrete is shaped to its purpose. They are constructed of wood or of steel; wood forms are most used. The cost of forms is a very large item in the cost of most kinds of concrete work; the contractor should, therefore, be assisted in every legitimate effort to make the greatest possible use of his forms. Safety must always come first, however; a great many concrete building failures have been chargeable to unwise handling of forms, particularly to the removal of forms before the concrete was hard and strong enough to carry its loads unsupported. The inspector should watch with care all portions of formwork having any bearing on safety. Forms being the molds in which the concrete is shaped, any error in dimension or alignment means a corresponding error in the molded concrete member. The inspector should also make certain that the forms are perfect for their purpose in these respects. It should be accepted as a cardinal principle in form inspection that: *The accuracy of no detail shall be taken for granted; it must be verified.*

Construction of Forms.—See that the construction of forms is such that they can be removed without injury to the concrete, and that they can be erected accurately. Construction which necessitates the use of heavy crow-bars or hand sledging to take the forms apart is dangerous to the concrete. The best form construction is one in which the parts are assembled by means of clamps and wedges, and not by nails.

Alignment of Forms.—See that all forms are erected in exact alignment, both vertically and horizontally; that column and wall forms are plumb; that girder boxes and wall forms are without winds or twists; that slab centers are level, etc. If the forms stand any considerable time between erection and time of depositing the concrete, check the alignment just before placing the concrete. Check the alignment after storms and high winds. Keep careful check on the alignment of movable panel forms used in wall construction; they require especial skill and care to keep in line. Watch the alignment during the placing of the concrete; the loading may distort the forms.

Strength of Forms.—See that all forms have ample strength to support properly the loads they are called upon to carry. Proper support of concrete in construction work means immovable support, not merely support sufficient to prevent collapse.

Rigidity of Forms.—See that the forms are rigid, immovable under the loads they have to carry.

Loads on Forms.—See that the loads on forms are restricted to those for which the forms are designed. These comprise the weight of the concrete and such necessary construction loads as the weight of workmen, runways, wheelbarrows, etc.

Storage of construction materials for future use on the forms should be prohibited.

Wetting of Forms.—See that all forms, if not coated with some oil, are thoroughly wetted on both sides before concrete is poured. A soaking wetting is necessary; see that the water is thoroughly applied to the boards until they will take up no more moisture. Even when the inside of the forms is oiled it is a good plan, especially on hot days, to wet down the outside of the forms thoroughly.

Oiling Forms.—See that the forms are oiled at each setting, just before depositing the concrete. Take care that an excess of oil or other unguent is not used; take care that spots from which adhering concrete has been cleaned are especially well oiled; concrete shows a tendency to stick again to the places on which it has once stuck. Never grease or oil forms where concrete is to be plastered or whitewashed; the grease will discolor the work and make the bond between coating and wall concrete poor.

Cleaning Forms.—See that all forms (beam boxes, column molds, wall forms, etc.) are carefully and thoroughly cleaned from shavings, chips, sawdust and adhering or accumulated foreign matters of all kinds before concrete is allowed to be deposited. The cleaning should be done just previous to placing the concrete.

Removing Forms for Finishing.—Where the surface is to be finished by scrubbing or other process requiring the concrete to be still green, see that proper provision is made in the construction of the forms for laying bare the concrete as fast as it reaches the required hardness.

Lumber for Forms.—See that the lumber for forms is of such quality, size and finish that it promises absolute stability and reasonably perfect work under the conditions. It is the contractor's right, if unrestricted by the specifications, to use such lumber as he pleases, providing he gives the results required, but it is the inspector's right to insist that the lumber used promises the specified results with reasonable certainty.

Quality of Lumber.—Lumber from weak and treacherous woods, that is cross grained, that contains knots, wind shakes, or rot which endanger its safety under the conditions, should not be allowed. See that the lumber is not so dry that when soaked by the concrete it will swell so as to bulge and distort the forms; see that the lumber is not so green that it will shrink so as to leave open joints.

Note.—White pine, yellow pine, spruce, Oregon pine and redwood are suitable for forms, hemlock is unreliable.

Size and Finish of Lumber.—See that the size of the lumber is such that it will not deflect, bulge or warp unduly under the conditions. See that it is straight and true and of even thickness. See that the finish is such as will give the surface results desired.

Cleaning Form Lumber.—See that form lumber which has been previously used is thoroughly cleaned of adhering concrete or dirt. The cleaning should be done before the lumber is again built into forms.

Fabrication of Forms.—See that the carpentry is workmanlike, the measures accurate, the lines true and square, the joints close, and the finish neat. Form work is not cabinet-makers' work, but it is good all around carpenters' work, and it should be done in a workmanlike manner. Watch particularly the piecing out of beam boxes, the alteration of column molds, etc.

Tight joints.—See that all joints in forms are fairly tight. Absolute water tightness is not demanded, but the joints should be close enough to prevent leakage of the liquid mass which will bleed the concrete of any material portion of its cement.

Beveling Strips and Moldings.—When beveled or rounded edges are specified, see that the proper beveling strips or moldings are placed in the forms. This is a minor detail, very likely to be overlooked by carpenters.

Spacing and Squaring Column Molds.—See that column molds are accurately spaced in all directions and that they are set square with the lines laid down on the plans. Figures 1, 2 and 3 indicate the kind of errors in spacing and squaring that should be watched for.

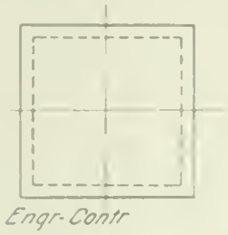

Fig. 1—Correct.

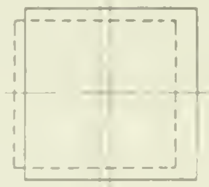

Fig. 2—Incorrect.

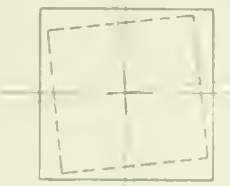

Fig. 3—Incorrect.

Cleaning Column Molds.—See that the column molds are cleaned with particular care. The bottoms of column molds are particularly likely to get the sweepings from girder boxes and other debris, and they are particularly hard to clean unless special provision is made for cleaning. A good practice is to require the bottom of the mold to be left open at one side until ready to place the concrete. This opening gives access for cleaning, permits examination for cleanliness and gives light by which the bulging of molds or blocks in the reinforcement can be detected by peering up through the mold.

Camber of Beam Forms.—See that beam and girder forms are given a camber to provide for settlement under load. By camber is meant setting the box slightly higher at mid span than at the ends. A common camber is ¼ in. for every 10 ft. of span.

Wire Ties and Spacers.—See that the wire ties for wall forms are in place and properly cut so as to pull the sides close against the spacers. The form of tie is shown by Fig. 4 of the text. See that the spacers are removed from the forms as soon as the concreting reaches them. Careless or lazy workmen will often simply knock them out and leave them embedded in the wall, or bury them as they stand.

Projecting Ends of Wire Wall Ties.—See that the projecting ends of wire ties used to hold together the sides of wall forms and left embedded in the concrete are cut off smoothly and flush with the face of the wall. A rust spot invariably forms on the face of the wall where the tie is cut off so that such ties should not be used where the presence of rust spots is prohibited.

Bolt Ties and Spacers.—See that the bolts are tightened against spacers set between the two sides of the forms inside. See that the bolts are enclosed inside the form with sleeves or are thoroughly greased, otherwise the bolt will stick and can be drawn out only by wrenching and tearing the concrete, and perhaps cannot be removed at all. See that bolt ties are not located close to a corner or face or the corner may be spalled off in pulling them.

Inclined, Pyramidal or Batter Forms.—See that forms for retaining walls with battered sides, pyramidal forms for column footings, etc., are firmly anchored down to resist the uplifting or floating effect of the semi-liquid concrete.

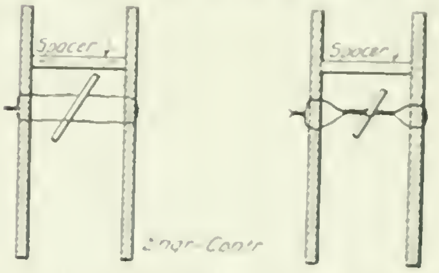

Fig. 4—Wire Tie For Forms.

Arch Centers.—See that arch centers are trussed, assembled and erected in a workmanlike manner. See that substantial foundations are provided for the center. See that suitable means are provided for striking or lowering the center gradually and without shock or jar to the concrete. See that allowance is made in erecting centers for settlement under load and for permanent camber. See that the lagging is of even thickness and is made smooth to give a good surface to the soffit of the arch.

Earth and Rock Section

Note: This Section is devoted to methods and costs of excavating earth and rock and building embankments. It will cover the grading of roads and railroads, diking and canal work, dredging, building reservoirs and earth dams, sewer and water pipe trenching, quarrying, etc.

Methods of Deep Well Drilling in the Gulf of Mexico Costal Plain.

The costal plains of Texas and Louisiana, now being rapidly developed as vegetable and rice growing areas by deep well irrigation, presented one of the most difficult problems ever encountered in deep earth drilling until a drill especially adapted to penetrate the formations encountered was invented.

The Texas Costal plain is developed on a stratification of sands, gravel, clays, and loams, spread in thin but usually extensive beds, separated by an occasional thin stratum of soft rock, the whole dipping gently to the east. These sediments extend to great depth, a well sunk at Galveston to a depth of 3,067 ft. being entirely in these formations. The alternating porous and impervious members of this region produce ideal conditions for artesian wells. Over the greater part of this area the rocks are of the Tertiary age, but in the interior border Upper Cretaceous sediments appear. In the costal region of Louisiana, the outcrop is usually of the Quaternary age, but most deep wells obtain their water supply from the Tertiary deposits underneath and the general conditions for deep drilling are very similar to the costal plain of Texas.

When oil was first discovered in the Corsicana and Beaumont, Texas, fields, a large number of makes of drills, operating by the spudding or churning method, were tried in these territories but after many months of effort in which not a single well was sunk to great depth by these machines and many drills became stuck in the wells by the caving quicksands encountered the holes were abandoned. A rotary drill, operated by the hydraulic jetting process which proved especially adapted for handling these formations was finally introduced. Practically all deep wells sunk in the costal plain regions of Louisiana and Texas are now put down by this method, many of them at the rate of 1,000 ft. a day.

The style of machine used varies considerably in different localities, depending upon whether small wells of moderate depths or large wells of great depths are required. For drilling small wells a portable outfit is usually employed. This consists primarily of loosening the earth with a hollow rotating bit and bringing it to the surface by the upward current of water obtained by forcing water down through the drill pipe, with a suitable style of pump, which is connected with the top of the pipe by a hose and water swivel. As a rule small wells are not cased until after the hole is completed. As a means of preventing the sides of the hole from caving while being sunk, which they would be certain to do were they not sealed, a large quantity of clay is thoroughly puddled with the water forced down the drill pipe and this penetrates the porous strata to a sufficient depth to make the walls of the hole stand. To furnish a water supply for the pump, a small reservoir, or sump, is first constructed divided by a partition, in one end of which a reserve supply of water is kept, and in the other, in which the suction pipe of the pump is located, clay is constantly added and puddled or rolled during the entire time the drill hole is being sunk. No other means has equaled this simple method of preventing the porous strata from caving.

In sinking the drill hole by this method, the water forced up outside the pipe washes out a hole much larger than the pipe so that it is usually possible to sink a permanent well casing 10 to 12 ins. in diameter in a well in which a 3-in. pipe was used in boring.

When the desired depth has been attained, the drill pipe is removed and the permanent well casing inserted. The first one, two, or three sections of the permanent casing are perforated to form a strainer near the bottom of the well. If the strainer is to be three lengths of pipe long, or say 60 ft., care is taken to insert in the casing three lengths of 3 in. pipe and the space between the inner and outer pipes filled with shavings so that it cannot fill with earthy matter when descending. In case it does not descend readily of its own accord, the lower end is fitted with a saw-tooth bit and it is rotated down by power in substantially the same manner as when sinking the drill-hole. The upper end of the interior 3-in. pipe carries a conical sleeve so that it can be caught readily by the threaded end of other lengths of pipe lowered afterward for drawing it from the well. When the permanent casing is sunk to the desired depth, the shavings are jetted out, the interior pipe drawn and the well pumped to remove any impurities forced down while drilling.

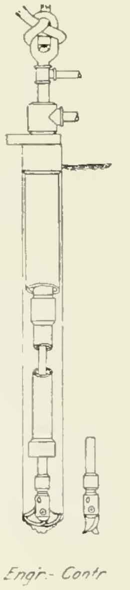

Fig. 1.

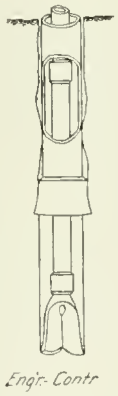

Fig. 2.

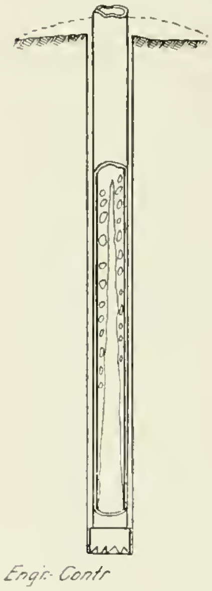

Fig. 3.

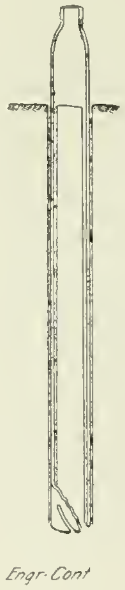

Fig. 4.

Fig. 1.—Showing method of getting down a well through either hard or soft material. The string of tools is churned up and down.

Fig. 2.—Showing method of sinking a well by the rotary hydraulic jetting process. The well is first drilled and then cased with piping.

Fig. 3.—Showing the method of sinking a well by the rotary hydraulic jetting process. The casing is sunk by means of the cutting shoe and the core washed out as indicated.

Fig. 4.—Showing method of taking a core when sinking a well through rock.

When a well of large diameter is sunk to a depth of 500 ft. or more a four-post derrick is usually erected, the standard height of which is about 85 ft. to admit of two or three lengths of pipe being swung into the well at one time. A power driven rotary machine, as illustrated herewith, is used and either the rotary or the engine equipped with a reverse gear. A pump is used having a two-way or a three-way cock in the discharge pipe, each of which is connected with a lead of hose to the end of which is attached a water swivel. A hoisting drum is carried in one side of the derrick frame near the base from which a rope cable extends over a sheave at the top of the derrick to the water swivel attached to the top of the drill pipe. Above the hoist in the derrick frame is carried a power shaft terminating at one end in a cat-head to which power is transmitted from the engine by a sprocket chain and another sprocket drive leading from this shaft propels the rotary.

The drill is either of the saw tooth type, as shown herewith, in which case it is usually attached to the pipe which forms the permanent well casing and the well completed at one operation, or it may be of the fish-tail, or "Paddy" pattern, with which the well is bored and cased afterward or the permanent casing may follow the drill down and the outer casing thus prevent the well from caving should quicksands be encountered.

When ground is firm the fish-tail drill is more rapid than the saw tooth for the reason that the center of the drill hole is chopped out instead of being washed out as is the case when the saw toothed type of drill is used.

When sinking wells in these alluvial deposits by the hydraulic jetting process, a valve opening downward is placed in the pipe, the object being to prevent the heavier mud and water on the outside of the pipe from coming up and settling in the pipe, when new lengths of pipe are attached. When additional pipe is to be added, two or three lengths are screwed together and attached to one of the idle water swivels connected to the pump and swung into position in the derrick over the well by means of a rope extending over one of the sheaves at the top and connecting with the cat-head. When everything is ready, the two or three way cock to the pump is turned, the gear to rotary or engine reversed, the water swivel in use unscrewed and by again reversing the gear the new pipe is added, the water cock opened into the new pipe and the connection is made in less than 15 secs. without stopping the pump, the improved machines performing all the work of unscrewing and screwing together the pipes.

Experience has proved that there is practically no danger of loosing a drill hole when drilling through caving quicksands so long as a flow of water is maintained through the pipe and for this reason it is very important that the addition of new pipe be made as quickly as possible as an interruption of the flow for only one or two minutes frequently means the loss of the drill-hole. By this method under perfect working conditions it is surprising how rapidly a drill hole can be sunk, in many instances the pipe sinking faster than new lengths can be attached in which case it must be supported while additional lengths are attached.

One size of pipe is frequently sunk 1000 ft by the hydraulic jetting process. Should an exceptionally hard rock stratum be encountered which this type of drill will not penetrate the well is cased to the rock and a rotary drill of a smaller size run into the casing to core through the rock. This type of drill is a plain tube of very soft iron having a slot extending upward and backward in a diagonal direction for several inches from the lower face. This drill is rotated in the same manner as the other types of drills except that it is churned or "jumped" a few inches in addition to the rotary movement. As a means of cutting the rock adamantine, which is small irregular pellets of steel chilled to extreme hardness, is fed down the drill pipe and carried under the face of the bit by the flow of water, the churning action and the slot in the drill bit feeding it under the face of the drill and imbedding it in the edge of the bit in a manner which makes it cut the rock very rapidly.

When the core is to be removed, the water is shut off and a few handful of gravel are fed in at the top of the drill pipe. The rotation of the pipe quickly wedges this between the core and the core barrel and snaps off the core enabling it to be removed by drawing out the drill rods. This operation is repeated until the rock is cored through when the well can be carried down to any desired depth by the jetting process using a smaller pipe.

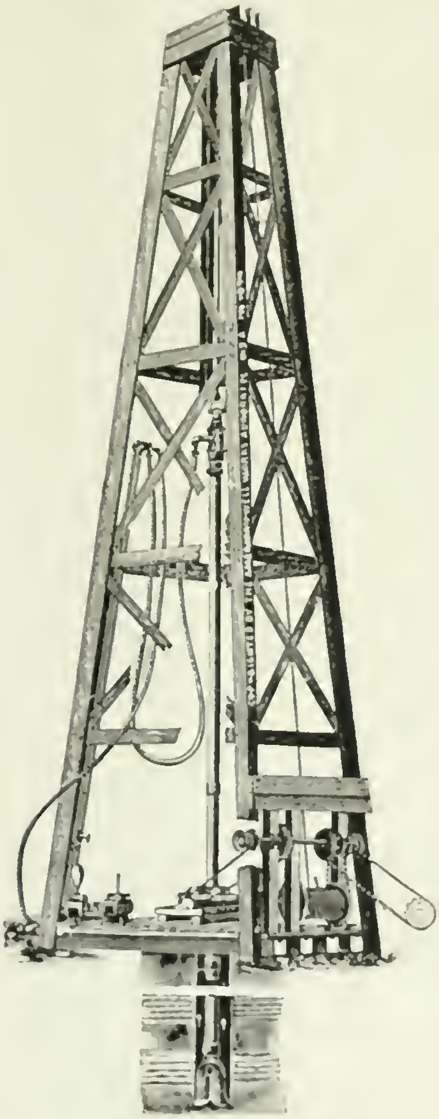

Fig. 5—Four Post Derrick Well Drilling Outfit.

Before this process was invented, no well was sunk in this territory to a depth greater than 700 ft, but with its adoption, wells of 1,500 to 2000 ft are frequently sunk with the record at 3007 ft.

We are indebted to the American Well Works, of Aurora, Ill., for the information upon which this article is based.

Comments on Dump Wagons.

(Continued from p. 226, March 24, 1909.)

In this series of articles we have already commented upon bottom dump wagons, including dump boxes and steam cars or wagons, and we have still to consider end dump wagons and special dumping wagons. We now take up end dump wagons.

The Studebaker Bros. Mfg. Co. of South Bend, Ind., manufacture seven styles of end dump wagons. They vary in capacity from 1 cu. yd. to $5^3/_4$ cu. yds., and each style is meant to be used for different classes of work. Most of these wagons are meant for city work, but some of them are also adapted for work in the country. The first one is known as the standard rear dump wagon. It dumps on the same principle as a dump cart but even without side boards is of much larger capacity. The body is low enough to allow of men shoveling into it, but side boards can be used to give it a capacity of $3^1/_2$ cu. yds. When so equipped the wagon weighs 2,500 lbs. There is a platform in front for the driver's seat.

Their second wagon is called a rear dump ash wagon. It is designed especially for handling ashes and garbage in towns and cities. It is shorter coupled than the other wagon and a little heavier, weighing 2,800 lbs. It dumps in the same manner, the driver, however, sits on the body of the wagon. The third wagon is the Allegheny rear dump wagon, which is meant for heavy hauling of any kind. The wagon has a capacity of $5^3/_4$ cu. yds. and weighs 3,500 lbs. The body is hinged on a long lever hinge that is controlled by a screw in the front of the wagon that rights the body.

The fourth style of wagon is known as the platform spring rear dump wagon. This wagon is meant for general contract work in cities and towns. It is equipped with regular truck platform springs. The tail gate is hinged at the top to each side of the wagon and, as the wagon is dumped, opens automatically. It has a capacity of about 3 cu. yds. and weighs 2,760 lbs. After the wagon is dumped it is righted by winding a crank on one side of the wagon. There is a set of standards on the front of the wagon to which the lines may be fastened while dumping.

The other three wagons are all made with steel bodies and without tail gates, the rear being built on such an angle as to discharge the load when the wagons are dumped. These wagons are equipped with covers and are designed primarily for wet garbage, sewage and soft muck and sand taken from manholes and conduits. The dumping arrangements are different in each model.

The Senderling Mfg. Co., of 647 W. 47th street, New York, are manufacturers of end dump wagons. To a great extent their business has been limited to the neighborhood of the city of New York, although they make wagons for both city and country use.

To understand more clearly the extensive use of end dump wagons in New York City, one must be familiar with the conditions affecting work there. For earth and rock excavation, and also for loading sand, broken stone and other building materials, derricks are used in most cases to load the wagons. Thus the height of the wagon is not as important as when the wagons are loaded by hand. Waste materials are dumped onto scows to be hauled out to sea, and building materials are dumped through chutes into the cellars. In handling garbage, ashes and refuse, end dump wagons are used as these materials are carried from the city by scows.

These conditions have given to the city of New York and vicinity an entirely new system of doing excavation work, both earth and rock, and of hauling sand, gravel, broken stone and other materials. The Senderling Manufacturing Co., knowing these conditions, have designed wagons to suit them. They have eliminated most of the hard axle wagons by mounting their dumpers wholly on springs and making them very compact and easy to operate. In addition to eliminating the excessive noise and clatter of the hard axle wagon on the city pavements, the springs have also prevented the spilling of part of the load on the streets.

This company manufactures three distinct classes of wagons, and under each of these classes there are several styles and sizes. The Standard Contractor's Dumper is meant for contractor's use in excavation and hauling. These, as originally built with hard axles, had a carrying capacity of only 1¼ cu. yds., but the newer wagons with springs have a capacity of 3 cu. yds. The 1¼ cu. yd. size weighs about 2,100 lbs., the 2 cu. yd. size weighs 2,750, while the 3 cu. yd. size weighs 3,400 lbs. These wagons are made with wide wagon beds so as to reduce the height. Their dumping angle is very acute, thus clearing the load quickly. The sills on which the bed rests are so shaped that the body, in dumping, rocks on these sills, which supports the body, until the box is near the ground, causing the body to strike the ground very lightly, thus preventing the wagon from being rocked.

The company also builds a brick truck for hauling brick and other materials. These trucks are made for both one and two horse teams and also of light and heavy construction. The two horse wagons are made with capacities of from 1 to 6 cu. yds. The light two horse wagon weighs 2,960 lbs., while the heavy one weighs 3,600 lbs. The light wagons will take a load of 1,500 bricks, and is meant to be used on soft roads.

The third class of wagons made by this company is the steel body dumper, which is made up to 12 cu. yds. capacity. These wagons are automatic in both dumping and in the return of the body to its seat after discharging its load, by simply starting the team ahead. The bodies are rustless, and many of them are made with covers to them. The rear end is shaped so it will dump its load easily.

The Western Wheeled Scraper Co., of Aurora, Ill., manufactures two styles of end dump wagons. The bodies of both styles are made of wood. One is a four wheeled wagon, while the second one has three wheels. The one with four wheels has the bed held in position by a hook at the front end, which is under full control of the driver's foot. It is also provided with an automatic end gate, held firmly in position when being loaded, and raised automatically when the body is dumped. The front wheels turn under the body, the wagon having a very short wheel base. This wagon is made in two sizes, namely 1 and 1½ cu. yds. When it is desired to spread the load directly from the wagon, it can be equipped with a device by means of which the opening for discharge is regulated. This wagon is an excellent substitute for the ordinary two wheeled dump cart.

The three wheeled wagon is much like a dump cart, but is lower, which makes it easy to load. The third wheel also takes the dead load off of the horse's back and neck. This wagon is of very simple construction. It is dumped and righted exactly like a dump cart. It weighs 1,550 lbs.

The Haywood Wagon Co., of Baldwinsville, N. Y., makes several styles of end dump wagons. These all have steel wagon bodies and are designed for hauling wet garbage, sewage and similar refuse. Two of these wagons have covers on them, and their rear ends are shaped to such an angle as to dump the load when the wagon is tilted. The third wagon has a tail gate that is worked automatically when the wagon is dumped. These wagons have capacities varying from 1 to 5 tons.

The Shadbolt Manufacturing Co., 68 to 78 Flushing avenue, Brooklyn, N. Y., also manufactures end dump wagons for general contracting and municipal purposes. This company makes a number of different styles of wagons, each designed for some special work, yet they are all built of wood throughout and somewhat upon the same general lines and principles. These wagons are all equipped with heavy springs. The body and frame upon which the body rests, are so built as to distribute the load over both front and rear axles, yet are so balanced over the rear axle as to dump easily. The sill is rounded off at the rear end so that the body rocks on it when dumping.

Attached to the front end of the body is a chain which passes through the top blocking and gear under the front axle. This chain passing under the axle in a measure takes off the strain or jar caused by dumping the body, the front springs acting as a cushion; the body is thus prevented from striking the ground at the rear end. This is said to admit of the body being drawn from under a load which is partially on the ground without tearing away the body or straining the horses. The chain can be lengthened or shortened at will, thereby determining the angle of the body when tilted which will need to vary to suit different conditions.

Some of these wagons have a tail gate hinged by a link hinge at the top, thus allowing the load to open the gate as it is dumped. Some of these wagons are equipped with a lever attachment to prevent the body from falling back in case the load should stick in the front end of body, thereby giving the wagon a tendency to right itself before the entire load is discharged.

These wagons are built to haul all kinds of materials and dump them, even lumber and lathes. They vary in capacity from 1 to 5 tons.

The American Road Machine Co., of Kennett Square, Pa., are the makers of the Champion distributing cart, which is an end dump wagon designed primarily for spreading on a macadam road. It can be arranged to spread over any width of road desired, and can also be adjusted to spread thicker on one side than the other. The tilting of the wagon is effected by means of a crank and gear mechanism in connection with a rack and pinion. The wagon can be firmly held in any position from level to completely dumped. The tail board is hinged at its upper edge, allowing the lower edge to swing out. Steel wings are attached to either side of the cart, at the tail board, for the purpose of spreading the stone to the entire width of the track of wheels. The stone, as it escapes from the wagon, is leveled by means of a steel scraper attached to the bottom of tail board. The scraper is pivoted in the center and is adjustable at either end by means of a horizontal lever on back of tail board. This cart is made in two sizes; the smaller size holds 1½ cu. yds., and the larger 2 cu. yds.

Geo. H. Holzbog & Bro., of Jeffersonville, Ind., manufacture two styles of end dump wagons. The first one is a large square box that dumps at the end. This wagon, designed for ash and garbage collection, is of large capacity. The second one is an all steel body, rounded on the bottom and dumps out of the end by being turned over. The body is really a tank, designed for carrying wet garbage, sewage and similar materials. The body is low, the height to the top from the ground being 4 ft. 8 ins. However, the body can be [illegible] and the height can be reduced to 3 ft. when the tank is [illegible] at a slight angle. The wagon is short coupled and is easily dumped, as the patented [illegible] there being no [illegible] such as have been found [illegible] stretching. The wagon has [illegible]. The weight of the regular four wheeled wagon is 2,125 lbs., and the capacity of its tank is 65 cu. ft. A larger size wagon is also made to hold 80 cu. ft. of material.

The Briggs Labor Saving Specialty Co., of Waterloo, Iowa, makes an end dump wagon. This wagon is meant to handle all kinds of material that will dump by gravity. The frame that holds the body is made of channel irons. The wagon can be dumped and righted without the driver leaving his seat, and can be arranged so as to dump the entire load in one place or else to distribute and spread the load. The tail gate is hinged at the top on a long strap hinge, and when the gate is to be opened wide chains on the bottom of it are fastened to the ends of the channels. This holds the tail gate high enough from the wagon body to prevent the load from striking it, and allows of rocks being dumped which are as large in diameter as the height of the sides of the wagon. This is quite a consideration in excavation work.

When the wagon is used to distribute its load, the tail gate is not held up in this manner. The wagon is short coupled, the wheel base being only about 5 ft. These wagons are made in six sizes varying from 1½ to 3 cu. yds. The four standard sizes are 1½, 2, 2½ and 3 cu. yds. and weigh respectively 2,300, 2,600, 2,850 and 3,000 lbs. The ordinary pole furnished with these wagons is loose, but a stiff pole can be furnished if desired. These wagons vary in height from 4 ft. 10 ins. to 6 ft.

The Hall Cart and Wagon Co., of Jersey City, N. J., also makes an end dump wagon. Their wagon is of the same general design as their dump cart. It has an all steel body, without a tail gate, with the rear end shaped to such an angle as to discharge the load when the wagon is dumped. This company's carts and wagons have been used extensively in New York city.

In the concluding article on dump wagons we will comment on special dump wagons and on the use of dump wagons for various purposes.

(To be concluded.)

The owners of grain godowns and warehouses in Calcutta are compelled by municipal regulation [illegible] to pave with concrete to prevent the ingress of rats, which, it is believed, will aid materially in the extermination of this active distributer of the plague germ.

Two Records of Costs in Drilling Rock with Electric Air Drills.

A description of the Temple-Ingersoll electric drill was published in ENGINEERING-CONTRACTING for May 27, 1908. This drill is operated by air impulses sent to it by a pulsator operated by electricity. The machine is manufactured by the Ingersoll-Rand Co., of New York.

Where electricity can be had for operating the pulsator and the drill is not needed for continuous work, [illegible] the drill has special advantages, as it is not necessary to keep up power during the whole day as must be done when the drill is operated by either air or steam. The pulsator is portable, thus allowing both it and the drill to be moved easily from place to place.

The Brier Hill Collieries, of Crawford, Tenn., have been using one of these drills, a 5 D, in their mines for about 18 months for drilling holes in the roofs of several entries. The rock varies from slate to sandstone and conglomerate rock, and Mr. E. B. Taylor, general manager of the mines, who has kindly furnished us with the information regarding this drill, states that the drilling was done through the hardest roof he had ever encountered in 30 years' mining experience.

A 5 D drill is equivalent to an Ingersoll-Sergeant 3½-in. drill, and has a stroke of a little more than 8 ins. It will drill a 16 ft. vertical hole from 1¾ to 2¾ ins. in diameter. It has a 5½ HP motor. Such a drill is intended for the heaviest work in large tunnel headings, open cut work in quarries or railroad grading, or in shaft sinking, or mining.

During 16 months' work with this drill holes were drilled in the roof of the main entry of one mine, a distance of 600 lin. ft., in driving three entries of another mine, a distance of 250 ft. in the [illegible] way, 200 ft. in the 2d left entry, and 275 ft. in the 3d left entry.

These three entries were driven simultaneously, the drill being moved from one entry to another as it was needed. Only one hole was drilled in the roof of each of these entries each day, the average depth of a hole being 7 ft. It took the drill runner and a helper from 20 to 30 mins. to unload the drill from a car and set it up, while the hole was drilled in about 20 mins. About a half day was consumed in drilling the three holes and making the necessary moves, more than [illegible] of the time being taken up in moving and setting up the drill.

With wages for the drill runner at $2.50 for a 9-hour day and $2 for the helper, this gives a labor cost of 13 cts. per lin. ft. of drilling. Upon one occasion the crew drilled 7 holes in a 9-hour shift, aggregating 42 ft. 6 ins., which reduced the cost to 11 cts. per lin. ft. Mr. Taylor states that during the 16 months this work was going on [illegible] sharpening the steel bits [illegible] necessary for maintaining the drill [illegible] record [illegible].

The Superior Portland Cement Co., of Superior, O., have recently had three of these drills at work in their limestone quarries. We are indebted to Mr. [illegible], manager of the company, for the following account of work done by these drills.

The bed of limestone averages about 8 ft. in thickness. To blast out the [illegible] holes 8 ft. deep and 2½ ins. in diameter are drilled. Each drill puts down on an average 17 of these holes per day. These three drills do 300 lin. ft. of drilling per day. They are blasted out to an average of 500 tons of limestone per day, equivalent to 220 cu. yd. This gives an average of 1.4 lin. ft. of drilling per cubic yard of rock blasted, place measurement.

With wages for the drill runner at $3.50 per day, and helper at $2 per day, this gives a cost for labor for drilling of 5.4 cts. per lin. ft. and 7.5 cts. per cu. yd. of rock blasted, which is a very low cost, accounted for, however, by the rapid drilling done by this machine.

Another factor that enters into the rapid work done by one of these drills is its tremendous back pull or stroke, making the drill work itself loose in a bad hole and preventing it becoming "stuck." Even when the steel binds, there is a pull and push on the piston at full power for every revolution of the pulsator, and this works it loose almost instantly. Mr. [illegible] states that the wear and tear on these drills has been very light.

The method of moving the pulsator and dynamo in the quarry was very simple. These two are mounted on a common bed which has two sets of wheels under it. A cheap wooden frame for a track was made in sections, for the track to rest on. Only a few of these sections were needed and they were light, convenient and easily handled. Small steel rails [illegible] also be made up in sections and used in the same manner, and generally they will give better service, as well as allow of a better joint being made between the sections. When a good hard bottom occurs in the pit or quarry, the pulsator and motor can be moved from place to place without the track, the wheels running directly on the rock. Or, again, it can be [illegible] over rough ground or [illegible] with the aid of blocks and tackle.

For other records of work done by these drills and the cost of maintaining them see ENGINEERING-CONTRACTING, Dec. 9, 1908, p. 392, and Dec. 23, 1908, p. 172.

The New York Central Lines have placed an order for 15,000 tons of steel rails.

The London Statist puts the world's production of gold in 1908 as the largest in history, or $[illegible], against $[illegible] in 1907 and $[illegible] in 1906.

Roads and Streets Section

Note: This Section is devoted to methods and costs of road and street construction. It will cover road building in all its details, the construction of pavements, sidewalks and gutters, the testing and use of paving materials and the machinery and tools used in road building and paving.

Mountain Road Construction in California With a Steam Shovel.

The State roads now owned by California and under the control of the State Department of Engineering all traverse the mountainous districts. No valley roads or macadam highways are under State supervision. The policy of the State has been to construct and maintain roads through territory where construction is expensive, and the counties through which they run are too poor to properly care for a road. Following out this policy, the State has constructed and has under construction a number of scenic highways, which open heretofore almost inaccessible parts of the state. Among the roads now under construction is the King's River Canyon Road, which will give access to the floor of the King's River country. This road will be one of the most important scenic highways of the State, and its construction is an extremely difficult piece of engineering work. The road begins at the end of the General Grant National Park, in Fresno County, California—a spot noted for its big sequoias—and extends easterly with a grade nowhere exceeding 6 per cent, through a timbered country, until it merges into the open at Indian Point, where one may see the grand Tehipite canyon. From Indian Point to Windy Cliffs, magnificent cliffs, waterfalls and rough mountain scenery are on all sides. In places along this stretch of road, it is necessary to build this road out of solid granite, with cliffs 1,500 ft. above and 1,000 ft. below. Beyond this section, and between Redwood Creek and the South fork of the Kings River, the road at one point suddenly emerges from the live oak timber on a ridge where it switches back. At this turn one may look below 1,500 ft. into a deep gorge with solid walls and no outlet. After reaching the river by a series of switchbacks, the road enters the gorge of the Kings River and then continues up stream for twelve miles to the floor of the canyon. The whole route is through a hard, rough country where no trails exist; a country few persons have seen or traveled through. The road is being constructed with a 12-ft. roadway, with turnouts at all points and inside curves to allow for the passage of teams. These turnouts are usually 100 ft. long and 18 ft. wide. Wherever the road traverses a steep, solid bluff the outer edge is to be protected with a parapet wall. All of the mountain roads of the state have earth beds.

View Showing Steam Shovel at Work in Rock on Kings Canyon Roads.

Surveys for the first 20.1 miles of the Kings Canyon Road were made in 1906 at a cost of $3,341.72, or $167 per mile. Surveys for the remainder of the distance were begun Aug. 17, 1907, and completed Nov. 17, 1907, at a total cost of $2,691.22, or $211 per mile. This 12¾ miles of road passes through the roughest part of the canyon and the surveys were conducted under great difficulties. Construction work was started in 1907 at the north gate entrance of the General Grant National Park and continued for a distance of 1.6 miles, the cost per mile being $4,040. Work was resumed on May 26, 1908, and continued until Oct. 28, 1908, when, on account of winter weather and the inability to hold men in that high altitude late in the year, work was discontinued. The work was continued by hand until about Aug. 20, when a 31-ton steam traction shovel, made by the Ohio Steam Shovel Co., and two small 2¼-in. Burleigh drills were placed on the work. The capacity of the shovel bucket was 1¼ cu. yds., and in earth, under a test, five throws or swings per minute were made. The shovel furnished steam to run the drills, and handled all rocks, earth, stumps, brush and trees up to 18 ins. in diameter. In fact it practically accomplished with a crew of eight men what 50 hand laborers had done before on the same class of work. While the steam shovel was going over a section of road, two men followed leveling the roadway, after which the earth bed was finished. Although the shovel was in use but one month before the work closed down for the winter, it was demonstrated that this was the quickest and cheapest way of constructing the mountain roads of California. Regarding this the last annual report of the State Engineer states:

View Showing Maximum Grade on Kings Canyon Road.

"It cuts the cost of hand work by 50 per cent in moving the class of materials en-

[illegible] untered on these roads [illegible] the width and alignment. A [illegible] earth must be cut out to permit of the shovel traveling in, while a [illegible] ridge, which ordinarily [illegible] now cut through with a great deal less cost. Large trees, stumps and brush are cast over the waste edge of the road with facility, so that the cost of grubbing the road is minimized. From the short operation of this shovel it is plainly seen and proven that the mountain roads of California can be built at much less cost than originally figured, if the traction steam shovel is used."

During 1908 3.5 miles of road were finished at a total cost of $13,103, or an average cost of $3,750 per mile. The average cost per mile for road constructed by hand labor was $2,330, the average cost per mile for road constructed by steam shovel was $1,300. It should be added that the steam shovel handled the hardest part of the work. The comparative costs of hand work and steam shovel work in earth excavation were as follows: Hand work, $0.35 per cu. yd.; steam shovel work, $0.08 per cu. yd.

The State highways of California are constructed under the general direction of the State Engineer, and we are indebted to Mr. Nathaniel Ellery, State Engineer, for the information from which this article was prepared.

Economic Hints for Macadam Road Contractors.

(Continued from March 31 issue.)

102. Most of the grading for roads involves very light cuts and fills. Hence the number of square yards of surface trimming per cubic yard of earth is very high, and the cost is correspondingly high per cubic yard. Railroad contractors are very apt to overlook this point when undertaking road building for the first time. A roadway 36 ft. wide, from out to out of ditches, has 21,000 sq. yds. of surface per mile. If the total excavation is 3,000 cu. yds. per mile, we have 7 sq. yds. of trimming per cu. yd. of excavation. According to the writer's experience a gang of men under a fairly good foreman will trim a hard earth surface to a depth of about 1½ ins., using mattocks, at the rate of 20 sq. yds. per man per hour, which costs ¾ ct. per sq. yd. when wages are 15 cts. per hr. Hence 7 × ¾ is 5 cts. per cu. yd. (distributed over the 3,000 cu. yds.) for trimming alone. Where the soil is a sandy loam the hand trimming costs half as [illegible].

103. Never use picks for such hand trimming, but use mattocks. A mattock cuts off much more material every blow.

104. Always use a road machine or a leveling scraper wherever possible for leveling subgrades. Using a two-horse machine like the 20th Century Grader and the Little Yankee Road Leveler, described in Hint No. 52, the writer has had a light growth of weeds and grass trimmed off the left shoulder of a road at the rate of 20,000 sq. yds. per 10-hour day, using two men and two horses, at a cost of one fortieth of a cent per square yard. A large [illegible]-horse road machine will readily level loose plowed earth at the rate of 25,000 sq. yds. per day.

105. Since most road specifications prohibit any vegetable matter in embankments, it is not unusual to see a gang of men ploughing up the sod and earth to a depth of 6 or 8 ins. and carting it away to be wasted alongside the embankment. This is an economic blunder. The sod can be removed to a depth of 1½ ins. with a mattock or with the blade of a road machine or of a leveler. In this manner very little earth is wasted.

106. Road embankments are seldom high. Therefore it is well to plant long poles in the ground at each "slope stake," making the top of the pole exactly level with the top of the proposed subgrade. By sighting along the tops of these poles it is easy to see whether the embankment has been built to the desired height. Teamsters must be cautioned about not knocking down these poles. The poles also serve to protect the slope stakes and prevent their being disturbed.

107. Every slope stake (the stake driven at each toe of the proposed embankment at each "station") should be marked on its front face (the face toward the road) with the fill to made above the level of the ground at the stake. F 1.3 means that the fill is to be 1.3 ft. above the ground level at the stake. (In similar manner, C 4.3 means that a cut of 4.3 ft. is to be made.) On the back of the slope stake should be marked the number of the "station." This point is often neglected by the road engineers. In which case, get some red "kiel" (a greasy red chalk) and mark the proper station number on every slope stake. Then when a slope stake is knocked out and dragged for some distance, its proper location can be ascertained.

108. The foreman should enter in a private note book, the cut or fill at every center stake, and at every slope stake, thus:

	Left	Center	Right
Sta. 10	F 2.6	F 3.2	F 1.1

Then if stakes are knocked out and lost he can replace them approximately himself. Moreover these notes can be used by the contractor in checking up the yardage moved.

109. It is stated in many books that embankments settle 10 to 15 per cent after they have been built. This is entirely wrong, and it is especially erroneous as regards road embankments. Even where the embankments are not rolled in layers, the settlement after construction is seldom as much as 2 per cent (¼ inch per foot of height), for the horses' feet and the [illegible] passed the [illegible] compacts the [illegible] shrinkage ranges from 1 to 3 per cent where it has not been rolled in layers.

110. Rolling in layers is often specified. It may cost anything between ½ ct. and 1½ cts. per cu. yd., depending on the judgment of the inspector and the character of the earth. Sprinkling is usually specified where rolling is specified. As much as 5 cu. ft. of water per cu. yd. of earth may be required. Refer to Hint Nos. 88 and 90 for costs of sprinkling macadam. Sprinkling earth embankments may be estimated from the data previously given. It will not ordinarily exceed 2 cts. per cu. yd. See Gillette and Hauer's "Earth Excavation and Embankments—Methods and Cost" (now in preparation).

111. One of the commonest causes of high costs of grading roads is the rehandling of earth. Sometimes this can not be very well avoided. Usually it can. The macadam is usually laid in a shallow trench (6 ins. deep x 16 ft. wide), and this is generally dug by hand, although in many instances it could be more economically dug with a plow and road machine throwing a windrow of loose earth to one side, which is then shoveled into wagons. But a common practice is to loosen this trench material and shovel it into small piles which are afterward shoveled into a wagon, thus causing one unnecessary handling. It is the writer's experience that for short hauls, a one-horse cart is preferable to a two-horse wagon for hauling this material dug from the "trench." There is necessarily a great deal of lost team time on this class of work, due to the fact that only a few men can be worked to advantage shoveling direct from the "trench" into the cart or wagon. The amount of the lost horse time is cut exactly in two by using a one-horse cart, and the driver loses no time at all, as he leaves the empty cart to be loaded while he drives the loaded cart to the dump. To illustrate: If 4 men are loading a cart from the "trench" they will spend, say, 8 mins. loading 1 cu. yd. If the same number of men are loading a wagon, they will spend 16 mins. loading 2 cu. yds. If the time of a horse is worth ¼ ct. per min., the lost horse time amounts to 2 cts. per cu. yd. on the one-horse cart and 4 cts. per cu. yd. on the two-horse wagon. In addition to this, it is seldom that the driver himself will do any shoveling, so that if he too is idle in loading a two-horse wagon his lost time amounts to [illegible] cts. more per cu. yd., making a total of 6 cts. per cu. yd. for lost team and driver time wherever it is possible to work only 4 shovelers to advantage in loading. The skimming nature of the excavation of the "trench" makes it uneconomic to crowd many around a wagon, for some of them will necessarily have to cast the earth a considerable distance and thus greatly reduce their daily output. Of course, where the excavation is heavier,

two-horse dump wagons should be used in preference to carts, particularly on long hauls.

112. Do not excavate the "trench" far in advance of the macadam, for it will be cut up by travel over it and may require retrimming and leveling.

113. Reserve any "sandpapering" of slopes and ditches until the road is entirely finished. Then put a good sized gang under a good foreman at work trimming up for final acceptance. Heavy rains will frequently cut the side slopes badly, necessitating retrimming unless this work is reserved till the last.

114. There is a vast difference in the skill of different men operating a road machine. Some leave a road subgrade "like the waves of the sea." Others cut to a grade that is almost perfect. When you find a good operator, pay him well and keep him. It is poor policy to have a mediocre man on any machine whose output should be large and at the same time of good quality. This is especially true of a road machine, for irregularities in the subgrade cause a loss of payment for much stone, if the macadam must be built to a prescribed grade line.

115. Pave all cobble gutters as soon after grading them as possible, so as to prevent washouts from rains. For the same reason, promptly sod all slopes that are to be sodded.

Data on Depreciation and Repairs of Steam Road Rollers.

Steam road rollers were first built in England about 1865, and it is to England that we naturally look for the most complete records of the cost of repairs and the life of these machines.

The English author, Thomas Aitken, has kept careful records for a period of more than 20 years, and his data are especially valuable not only to English but to American road builders.

Aitken gives the following table of first cost of English rollers:

15-ton roller, single cylinder	$2,300
12-ton roller, single cylinder	2,000
10-ton roller, single cylinder	1,875

Aitkin puts the life of a roller at not less than 25 years. He estimates 8,000 tons of stone consolidated by a 15-ton roller each year.

Aitkin gives the following cost of repairs on a 15-ton roller, which he regards as typical.

"Up to the fourteenth year the repairs were comparatively trifling, with the exception of a pair of new driving wheels and repairing the fire box and tubes, etc. These latter, and including sundry repairs, amounted, on an average, to $55 per annum. It was then found necessary to have a new fire box and general overhaul of all the working parts. This cost $850, and the engine should, it is anticipated, be capable, with ordinary repairs, to run for a period equal to a life 25 years at least."

Aitkin puts the total cost of renewals and repairs of a $2,300 roller at $105 a year during a life of 25 years, which is nearly 5 per cent of the first cost each year. To this must be added a percentage to cover depreciation, that is to provide a sinking fund sufficient to buy a new roller at the end of 25 years. If such a sinking fund draws 3 per cent compound interest, it requires that about 2.75 per cent of the first cost of the roller be set aside annually to amount to the full first cost of the roller in 25 years. This 2.75 per cent depreciation fund allowance if added to the 5 per cent for repairs and renewals, gives a total of nearly 8 per cent per annum.

Aitkin says that this is equivalent to 83 cts. per working day. Since 8 per cent of $2,300 is $184, if we divide the $184 by $0.83, we find that Aitken apparently figures on 221 working days in the year, which is almost double the number of days commonly worked by a roller in the northern part of the United States. (See Engineering-Contracting, May 23, 1906, July 3, 1907 (p. 7), June 10, 1908 (p. 358) for data as to the number of days worked in Massachusetts, and the cost of roller repairs.) Aitkin says that his estimate relates to a roller used in macadam repair work, "practically in steam all the year, except when under repairs or stopped by frost during winter months."

There is a seeming discrepancy in his figures, for he rates a 15-ton roller as capable of compacting at least 64 tons of macadam per day of 9 hours, if not interfered with by traffic. Elsewhere he estimates the "useful effect of one roller at 8,000 tons of macadam per annum," from which it would appear that less than 150 full days would be worked, or that delays due to traffic would cause a serious loss of time.

The writer's experience is that 75 tons of macadam can be compacted per 10-hour day, and that a contractor can usually count on about 100 to 110 days actual work, which gives a total of some 8,000 tons (including screenings) compacted each season by a 10-ton roller.

Regarding the repairing of the driving wheels, Aitken says:

"The renewal of the driving and front wheels, especially the former, is an expensive item, and what was considered at one time impracticable can now be carried out, that is, plating the worn out rims. This results in considerable saving, and the wear of the metal forming the rims is considerably less than in the original wheels. It should be stated, however, that the wheels for renewal of rims should not be worn too thin, as, in such cases, the renewal is not so satisfactory. The process is to fit steel plates on the old rims and rivet the two together, and, apart from a few of these becoming loose, which can be remedied by counter-sunk bolts, the arrangement is in every way successful. The gripe or 'bite' of these steel plated wheels is as good as that of the original cast-iron ones, and the wear is much more uniform."

Aitken goes on to state that the wear of these steel plated rims is 0.02 in. for every 1,000 tons of macadam consolidated, and that the cost of repairing the driving wheels by this method is $200 as against $250 for a complete set of new wheels, and that "experience shows that the life of these renewed with steel plates is nearly doubled."

There seems to be enough merit in this method of repairing the driving wheels to warrant the manufacturer's making them with removable steel plate rims in the first place. If the plates were of manganese steel the life would probably be three to four times as long as when made of ordinary steel.

Aitken states the cast iron driving wheels of a 15-ton roller lasted 7 years, during which time they consolidated 60,000 tons of macadam.

The Work of the New Orleans Municipal Asphalt Plant in 1907-08.

In our issue of February 5, 1908, we described the municipal asphalt repair plant of New Orleans, and gave a resume of its first year's work. The second year of service of the plant closed on Aug. 31, 1908, and a report covering its operations during this period has been prepared by W. J. Hardee, city engineer.

During the past year the total cost of work done by the municipal repair plant was as follows:

Repairs of asphalt pavements	$27,545.59
New asphalt pavements	14,409.33
Other kinds of new pavements	23,445.84
Miscellaneous improvements	74,398.91
Total	$139,799.67

It will be noted that only about 20 per cent of the above total was expended for the repair of asphalt pavements, for which purpose the plant was primarily established. The total number of square yards of asphalt pavement maintained during the year was 353,114, the gross cost, including special charges and general charges, being $27,545.59, or an average of 7.8 cts. per sq. yd. The average cost during the previous year was 11.44 cts. per sq. yd., the difference being due to the fact that when the repair plant was first put in operation the asphalt pavements had been very seriously neglected for a number of years and the first repairs were necessarily expensive.

The repair work consisted of the construction of 2,640 sq. yds. of naphtha coat and 24,081 sq. yds. of asphalt wearing surface, the cost per square yard of wearing surface being as follows

	Total.	Per Sq. Yd.
Materials	$8,831	$0.367
Labor	6,778	0.281
Proportion special charges	3,153	0.131
Proportion general charges	8,784	0.364
Total	$27,546	$1.143

It should be noted that no allowance has been made for interest on capital invested, nor has allowance been made for depreciation of plant. In the first annual report the cost of the plant including equipment is given as $70,583. Additions to the plant costing $1,261 were made in the second year bringing the total investment for plant and equipment up to $71,844. It should further be noted that the asphalt used cost only $19 per ton delivered.

The new asphalt pavement work consisted in the construction of 7,550 sq. yds. of pavement, the work including 11,580 cu. ft. of concrete, 7,550 sq. yds. naphtha coat and 7,550 sq. yds. 2-in. wearing surface. The gross cost of this was $14,109 or about $1.90 per sq. yd.

The other new pavement work consisted in the construction of vitrified brick and gravel roadways, the total cost of the work being $23,445.84. The largest item of work was for miscellaneous improvements, those consisting of graveling roads, constructing oyster shell pavement, grading, etc. The total cost of these miscellaneous improvements was $71,398. Each work executed by the municipal repair plant was charged with the actual amount of materials and labor employed and in addition there were fixed expenses subdivided into special charges and general charges which were charged to the work. The special charges which were proportionally apportioned to the cost of repair of asphalt pavements and to the cost of new pavements included labor unloading materials at plant; labor turning out asphalt wearing surface mixture, hire of extra teams, etc. The total cost of these charges was $6,178.

The general charges were proportionally apportioned to the cost of repair of asphalt pavements, to the cost of new asphalt pavements, other new pavements and to miscellaneous improvements. The net amount of the general charges was $41,580, the principal items being: Salaries of annual employes, $20,561; labor at plant and hire of extra teams, $2,705; live stock feed $4,736, hire of extra teams, $6,039, hauling and handling old materials, $5,710. The municipal plant forces worked every day throughout the entire year, excepting Sundays, non-working holidays and days when it rained. The output of the plant was 86,001 cu. ft. of wearing surface mixture, which was employed in new pavements and repair of old pavements. The crusher operated in connection with the asphalt plant crushed 7,831 cu. yds. of old stone at an average cost for labor and electricity of 51.1 cts. per cu. yd. The stone was furnished free of charge. The cost per cubic yard in the previous year was 46.66 cts. Including feed, hostler and stable boy's wages, veterinary's salary, shoeing, medicine, etc., it cost an average of 76 cts. per head per day to feed and care for the live stock, as against 61.9 cts. for the year ending Aug. 31, 1907.

The following table shows the amount and cost of materials purchased and handled in connection with the plant from Sept. 1, 1907 to Aug. 31, 1908.

	Total.
Asphalt, 434 tons	$8,272
Residuum oil, 76,845 lbs.	686
Naphtha, 3,045 gallons	317
Lake shore sand, 1,709 cu. yds.	1,811
River sand, 1,502 cu. yds.	2,478
Mineral dust, 268 tons	1,544
Cement, 913 bbls.	1,252
Coal, 384 tons	1,033
Clay gravel, 13,257 cu. yds.	21,106
Pine wood, 36 cords	264
Oak wood, 29 cords	196
Oats, 156,053 lbs.	3,039
Hay, 612 tons	1,106
Lake shells, 2,562 cu. yds.	3,578
Brick bats, 865 cu. yds.	1,388

Cost of Macadam Road Construction in Allen County, Indiana.

Allen county, Indiana, has many miles of excellent gravel roads, and in the past few years has also constructed a considerable number of macadam roads. The largest improvement of this kind was completed last fall in Maumee township. The construction of this road was described by Mr. G. F. Martin of Lafayette, Ind., in a paper read before the Indiana Engineering Society, and the following matter has been taken from his paper:

Maumee township lies on the east side of the county next to the Ohio line. The soil is a kind of black muck, easily cut up, and hauling over the dirt roads in the wet season was almost impossible. The town of Woodburn on the Wabash R. R. lies almost in the center of the township, and the roads were constructed in a system leading to Woodburn, which is the market town for the township. The recently improved road was constructed on the double track system, with the macadam portion on the right for teams going toward Woodburn. The highway was 40 ft. wide, with the grade 26 ft. wide on the top, the macadam portion being 10 ft. wide from the center line of the grade, with a 3 ft. bank to hold the stone in place. The stone was placed 10 ins. deep on the sides and 12 ins. deep in the center. One inch of screenings was placed on top of this, 7 ft. wide, as a top dressing. Crusher-run stone was specified to be used, but owing to its irregular composition ruts were formed in the road. Two and a half inch stone was then used for the lower course with quarter inch screenings on top. The stone was furnished by the Erie Stone Co. and came from the Huntington quarries. The length of the system of roads was 60,652 ft. or 11.487 miles.

The contract for the entire improvement was let to the Erie Stone Co. for $32,792.50 or $2,854.75 per mile or $1.62 per lin. yd. The only grading to be done was to smooth the road off to receive the stone [illegible] up and [illegible] where [illegible] was made. The grading was [illegible] but on the average [illegible] cost $1.10 per cu. yd. on the cars in Woodburn. The average cost of hauling it to the road was 20 cts. per cu. yd. or 10 cts. per cu. yd. per mile. Two yards to a load were hauled, the farmers in the vicinity doing the work. Teamsters were required to dump the wagons, though laborers were furnished at the cars to load them. Spreading the stone on the road cost 14 cts. per cu. yd. The road was drained by 4-in. tile on each side of the road where tile was not already in. This cost about 6 cts. per lin. yd. A roller was not used on the work, action of the teams hauling over it being depended upon to pack the stone.

The township was bonded for $34,080 to furnish money for the improvement. These bonds were of forty equal series of $852 each, bearing date of July 15, 1907, the first payable May 15, 1908, and one each succeeding November 15 and May 15 until all were paid. The bonds bore interest at 4½ per cent making the interest $19.17 every six months on each bond. The entire issue was sold at par. To meet the payment of these bonds a tax levy of 18 cents per hundred dollars was made in Maumee township.

The following table shows a résumé of the cost data:

Cubic yards of stone per mile	1,980
Cost per cu. yd. of stone on cars	$1.10
Cost of haul per cu. yd. per mile	0.10
Cost of spreading per cu. yd.	0.14
Cost per cu. yd. of stone in place	1.44
Square yards per mile of roadway	5,867
Cost of grading per sq. yd.	0.00
Cost of finished roadway per sq. yd.	0.48½

The town of Woodburn, a place of about 300 inhabitants, seized this opportunity to improve its streets. Two streets were improved with concrete curb and gutter and two with stone alone. The improvement in the town was under separate contract with the Erie Stone Co. The average cost of grading was 15 cts. per cu. yd. Stone cost $1.10 per cu. yd. and hauling and spreading 10 cts. per cu. yd. The actual cost for hauling and spreading was less than 25 cents per cu. yd.

Concrete curb and gutter were constructed with 6-in. curb and 18-in. gutter, 12 ins. deep, for 35 cts. per lin. ft. Headers of curbing alone were constructed for 15 cts. per lin. ft. Combined curb and gutter sewer inlets were placed for $7.50 each, and man hole covers for the catch basins at $1.50 each. The catch basins were built by the town. Cement sidewalk was constructed under the same contract for 12 cts. per sq. ft.

A bill is before the New Jersey Legislature authorizing the city of Newark to expend $2,000,000 for constructing a street car subway.

Water-works and Sewer Section

Note: This section is devoted to methods and costs of constructing sewers and water-works. It will cover the construction work for all details of water supply and sewerage, including sewage purification and water filtration.

Methods and Cost of Constructing and Laying Cement Lined Water Pipe at Plymouth, Mass., and Portland, Me.

Two general methods of building wrought-iron cement-lined pipe have been used in this country; the first, known as the Goodhue & Birnie pipe, the second, known as the Phipps patent.

The Goodhue & Birnie pipe was generally made by riveting up sheets of wrought iron, single riveted with cold rivets, without any attempt to make the joints water-tight, and lining this wrought-iron shell with from ¾ to 1-in. of neat Rosendale cement, or cement mortar mixed 1 part of cement to 1 part of sand. This work was generally done in a central plant, or at different points along the pipe line, from which the pipe was carried to the trench, there imbedded in Rosendale cement mortar laid along the bottom of the trench, and then covered over the sides and top with a ¾ to 1-in. layer or casing of Rosendale cement mortar plastered on with rubber gloves or trowel in the hands of the pipe maker. The trench was generally backfilled immediately or shortly after laying the pipe.

The pipes were made in lengths of 9 ft., and the joints between the pipes were made by means of a sleeve of wrought iron with inner and outer casing of cement, or by making the pipe tapering so that the end of one pipe was fitted into the end of the next. In the larger mains the joints were often plastered on the inside after laying; in the smaller ones, this was, of course, not attempted.

The Phipps patent pipe was generally made and coated without as well as within with a ¾ to 1-in. layer of cement or cement mortar, the outer coating being held in place by a thin sheet of wrought iron which subsequently rusted out in the trench. This outer sheet was of distinct advantage, however, as a protection to the outer cement coating in the handling and laying of the pipe.

In a few cases cast-iron bells and spigots have been riveted to the wrought-iron sheets before making the pipe, and the joints have then been made in the ordinary manner with lead tightly calked in place or by the use of cement mortar.

More recently under the Phipps patent, a type of cast-iron ring has been developed which is driven home in each end of the pipe,—one of the rings being a female ring, the other a male ring—thus more rigidly holding the end of the pipe and preventing injury to it in transportation and laying, and incidentally making more convenient the placing of the outer cement coating of the pipe, which is made of grout poured into the mold between the inner and outer sheets, with the pipe standing on end. The joint between pipes is made finally by the use of a sleeve as heretofore.

So far as the writer is aware no cast-iron joint has thus far been developed which has proven thoroughly satisfactory and advantageous from the standpoint of economy.

It is perhaps worthy of note that while blue annealed *wrought-iron* sheets imported from England were used in many of the early installations, in making the later ones steel has been substituted at some saving in cost, though not in durability.

Plymouth, Mass.—Plymouth is a town of about 11,000 inhabitants and has had a water supply since 1776. Until 1855 the water was supplied to the town by a private company and the pipes used were wooden logs with holes bored in them. In 1855 the town purchased the plant from the company, and the use of cement-lined pipe dates from that period.

At that time about 16,000 ft. of 10-in. pipe was laid and several thousand feet of 8-in., 6-in. and 4-in. pipe were laid for the distribution system. Practically all of the pipe laid at that time is still in use.

The pipe as then manufactured consisted of a sheet-iron shell about 9 ft. in length, lined on the inside with about ½-in. of cement mortar, composed of cement and sand in proportions of 1 to 1. The pipe was then laid in a bed of cement mortar in the trench, ends butted together, with a steel sleeve or collar at each joint. The top and sides of the pipe were then covered with two or more inches of cement mortar, all of the same proportions as used for the lining, and a cement-mortar joint was made at each joint of the pipe.

This pipe is still in use and withstands a varying pressure in different sections, from a few pounds to about 50 lbs.

In 1900, somewhat over 40 miles of pipe from 4 to 20 ins. in diameter was in use. At this time a change in the method of making the pipe was introduced, and for the past seven years all extensions have been made with a pipe manufactured in the local water-works shop, which is furnished with mechanical devices and power machinery necessary for economical manufacture.

The following description will make the present method of construction clear. The pipe consists of a shell, a jacket, male and female rings, and sleeves. The shells and jackets are of soft steel and are received at the shop in flat rectangular sheets of proper size and gage. For the shells of 18-in. pipe about 30 tons of steel sheets of No. 13 gage were used, at a cost of about $50 per ton for the sheets.

The gage of the sheets used for the shells of pipes of different sizes is as follows:

24-in.	12 gage	10-in.	17 gage
18-in.	13 gage	8-in.	18 gage
16-in.	13 gage	6-in.	19 gage
12-in.	15 gage	4-in.	20 gage

The jackets are all No. 26 gage iron.

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*Extract from a paper by Leonard Metcalf, M. Am. Soc. C. E., presented to the New England Water Works Association, Dec. 9, 1908.

TABLE I.—COST OF MAKING CEMENT-LINED PIPE AT PLYMOUTH, MASS.

Date.	Size, ins.	Length, ft.	Shell.	Jacket.	Sleeve.	Rings.	Rivets.	Cement.	Paint.	Labor.	Total.	Cost per ft.
1901	6	5,282	$650.94	$326.90	$42.25	$154.17	$25.98	$356.30	$7.14	$513.30	$2,076.98	$0.393
1901	4	2,461	186.20	104.74	12.37	43 89	12.29	162.15	1.50	281.25	804.39	0.326
1901	10	5,097	146.08	407.43	88.42	255.17	36.42	551.55	10.67	885.45	3,381.29	0.663
1901	6	2,007	221.34	100.71	14.02	58.18	10.03	135.41	2.66	177.09	719.44	0.358
1901	12	981	305.28	182.40	25.07	55.12	7.00	121.26	2.67	177.08	875.88	0.893
1907	16	8,109	3,722.80	852.72	337.50	1,363.35	61.90	1,728.00	15.00	1,954.42	10,035.69	1.24
1907	14	2,183	953 44	199.40	59.00	318.60	23.60	384.68	5.00	535.72	2,479.40	1.13
1907	18	7,680	3,751.60	896.40	298.80	1,460.80	119.00	1,826.00	18.00	2,457.60	10,828.20	1.41

TABLE II.—COST OF LAYING CEMENT-LINED PIPE AT PLYMOUTH, MASS.

Date.	Size, ins.	Length ft.	Labor.	Branches, gate and hydrant.	Pipe.	Cement.	Miscellaneous.	Total.	Cost. per ft.	Remarks.
1901	12	1,292	$861.90	$418.81	$1,128.62	$70.20	$55.00	$2,534.53	$1.96	Also 47 ft. 6-in pipe.
1901	10	5,430	2,478.28	1,292.21	3,583.47	205.40	173.48	7,732.84	1.43	105 ft. 6-in., 77 ft. 12-in., 40 ft. 8-in.
1901	12	1,292	458.40	108.72	1,153.76	52.00	54.22	1,827.10	1.41	
1904	8	3,007	1,035.66	275.67	1,503.50	91.20	72.99	2,979.02	0.99	
1904	6	2,543	1 134.97	412.33	933.28	61.88	37.55	2,584.01	1.02	
1905	6	4,550	1,854.23	491.38	1,966.16	96.00	385.82	4,793.59	1.05	Includes 4 hydrants and changing 25 services.
1907	18	6,545	4,248.80	232.00	9,228.45	440.60	523.60	14 673.45	2.24	
1907	14	2,031	552.52	141.00	2,295.03	124.20	86.00	3,201.27	1.56	
1907	16	8,891	4,820.00	1,411.12	11,024.84	420.00	1,179.39	18,855.35	2.12	

TABLE III.—COST OF BUILDING [illegible] FT. [illegible]-IN. WROUGHT IRON CEMENT LINED SUPPLY PIPE FROM END OF 26-IN. PIPE ON WARD'S HILL TO THE CITY OF PORTLAND IN THE YEAR 187[illegible].

Right of way and damages, etc.	$1,7[illegible] 14
Cast iron pipe, special, castings, valves, etc.	[illegible]24 6[illegible]
Wrought iron sheets for pipe: [illegible] lbs. at [illegible] cts., $[illegible] [illegible] lbs. at [illegible] cts., [illegible]	11,068 42
Making pipes 9 ft. long: 1,[illegible] pieces at $2.15 and [illegible] pieces at $2.0[illegible]	1[illegible],7[illegible]
Making joint rings, inside rings and special rings: 7,001 rings weighing 646,[illegible] lbs. at [illegible] cts. approximately per lb.	1[illegible],61[illegible] 14
Total labor, [illegible] days at $1.28 approximate average, day labor being paid from $1 to $1.[illegible], foremen $[illegible]	21,8[illegible] [illegible]
Cement, [illegible] bbls. Rosendale	20,180 [illegible]
Freight, cartage, etc.	1,118 [illegible]
Engineering, incidentals and miscellaneous expenses amounting to [illegible], approximately	10,919 67
	$143,913 92
Deduct land damages	1,[illegible]9 14
Net amount	$142,[illegible] 78
Cost per foot	$2.26
Equivalent cost per foot for year 190[illegible] (estimated)	$2.02

The operation of making the pipe is as follows:

The shells are punched in a punching machine. The spacing of the rivet holes is ¾ in. c. to c., the edge of the rivet hole being ⅝-in. from the edge of the sheet. The sheets are then put into the rolls and given a semi-circular form, as two sheets are used for the manufacture of one shell for the 18-in. pipe. After being rolled, the shells are riveted by hand, using 5/16 rivets with a 3½-lb. hammer, on a stake, so-called, which is simply a bar of iron about 10 ft. long, the upper surface of which is curved to approximately the same radius as the shell of the pipe which is to be riveted. The jackets are punched, rolled, and riveted in precisely the same manner as the shells and are 1½ ins. larger in diameter.

The rings are of cast-iron, a male ring for one end of the shell and a female ring for the other, the female ring being concave and the male ring convex, thus enabling a very tight joint to be made when the pipes are fitted together in the trench. About thirty tons of these rings were used in the manufacture of 16 and 18-in. pipe during the past year and the cost of the rings was 4 cts. per lb.

The next operation, after the shells are riveted, is the fitting in of the rings, and as they are made just for a driving fit into the shell they are driven in by use of the maul. After the rings are in place the shells for the 18-in., 16-in. and 14-in. pipes are lined by hand and the smaller sizes of shell from 12 in. to 4 in. are lined by means of a revolving cone. Neat Rosendale cement is used in lining. About 1000 bbls. of cement have been used during the past year in the manufacture of pipe, and the cost was $1.20 per bbl. delivered at our shop.

When the shells are ready to be lined by hand they are placed horizontally on two horses. A man stands at each end of the pipe with a long handled pallet knife, and is enabled to spread the cement smoothly in the pipe. The knife is simply a flat blade about 1½ ins. wide and 4 ins. in length with a handle about 4 ft. long. The cement for lining is mixed by hand in mixing boxes, and there are two men to mix for the two men who line. As the pipe lies on the horses it is lined for its whole length and half way up each side. Then the cement is allowed to set, after which the pipe is rolled over and the remaining half lined. After the cement has been smoothly spread about ½ in. thick, on the inside of the pipe, any irregularities which appear are corrected by the use of the 'nigger head,' which is a stiff brush on the end of a long handle. This brush in the hands of a skillful workman can bring the interior of the cement pipes to a very smooth surface.

At this point it may be well to describe the operation of lining the smaller sizes of pipe. The shells having been punched, rolled, and riveted, and rings put in in precisely the same manner as previously described, are stood upright on an elevator which descends into a pit. In this pit is the cone, so-called, which has an external diameter equal to the internal diameter of the shell when lined—in other words, about an inch smaller in diameter than the shell—placed and held directly over it on the elevator. The cone revolves on a vertical axis and cement mixed by machinery is put in at the top of the shell as it stands on the elevator over the cone. The top of the cone, extending for a few inches into the bottom of the shell, holds the cement from falling through into the pit. The elevator holding the shell is then lowered and the cone revolving at the same time spreads the cement smoothly and uniformly on the inside of the shell.

TABLE IV.—COST OF BUILDING [illegible] FT. [illegible]-IN. WROUGHT IRON CEMENT LINED PIPE FROM SEBAGO LAKE TO THE JUNCTION ON WARD'S HILL WITH [illegible]-IN. PIPE LEADING TO THE CITY OF PORTLAND IN 18[illegible].

		Per lin. ft.	Equivalent present prices per lin. ft.
Wrought iron sheets, No. [illegible] Birmingham gage, [illegible] lbs. at [illegible]		$[illegible]	$[illegible]
Punching, rolling, riveting and finishing [illegible] pipe 9 ft. long at $[illegible], equivalent to [illegible]	[illegible]	[illegible]	[illegible]
Rings	[illegible]	[illegible]	[illegible]
Total, 18[illegible]	[illegible]		
Total, lbs.	[illegible]		
Cement (Rosendale) [illegible] bbls. at $1.[illegible] and $1.[illegible] per bbl.		[illegible]	[illegible]
Contract for laying		[illegible]31	[illegible]
Valves		[illegible]	[illegible]
Specials		[illegible]	[illegible]
Lumber		[illegible]	1,074
Contract work		141	[illegible]
Total		$71,[illegible]	$[illegible]
Cost per foot (including 11.4% for engineering and contingencies)		$2.[illegible]	$[illegible]

The next operation is filling and grouting the pipe. The shells are stood on end around the edge of a platform which is about 6 ft. above the floor. A clamp is placed around the bottom of the shell about 8 ins. from the lower end, and the jacket lowered from above fits into the clamp at the bottom. The jacket is kept symmetrical with the shell at the bottom by means of this clamp, and at the top by means of four wedges. The grout is merely a mixture of neat cement and water, mixed to such a consistency that it will pour readily, and is mixed by machinery in a cylindrical mixer which has four paddles. After being thoroughly mixed, the grout is poured into a metal bucket which is suspended by a chain with a wheel and is carried on a track around the platform. The grout is poured from the bucket between the shell and jacket of the pipe that has been stood around the edge of the platform. After the grout has been poured, the pipes are allowed to set twelve hours.

TABLE V.—ESTIMATE OF COST OF REPRODUCING CEMENT LINED PIPE IN PORTLAND.

	26-In.		24-In.		[illegible]-In.
	Actual price and quantity	Estimates for present conditions	Actual price and quantity	Estimates for present conditions	Estimates for present conditions
Cost of sheets, per lb.	$0.0342	$0.02[illegible]	$0.0[illegible]	$0.0[illegible]7	$0.0[illegible]
Cost of cement, per bbl.	1.40	1.00	[illegible]8	1.[illegible]	[illegible]
Cost of joint castings, per lb.	0.028[illegible]	0.0[illegible]7	[illegible]	0.0[illegible]7	0.027
Cost of making pipe, per lb.	0.00[illegible]	0.01[illegible]	0.0[illegible]	0.01[illegible]	0.01[illegible]
Weight per foot, lbs.	[illegible]		[illegible]		[illegible]
Bbls. cement per foot	0.1[illegible]		[illegible]		[illegible]
Weight joint rings, lb.	[illegible]		[illegible]		7[illegible]
Weight joint rings per foot			[illegible]		[illegible]
Cost per linear foot of:					
Sheets	$1.2[illegible]	$[illegible]	$[illegible]	$[illegible]	$[illegible]
Making pipe	0.[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Joint castings	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Cement	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Gates, valves, etc.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Labor and laying	[illegible]8*	[illegible]	[illegible]	[illegible]	1.[illegible]
Sum	$[illegible]	$1.[illegible]	$[illegible]11	$[illegible]	$[illegible]
Total actual cost, including all special details, engineering and contingencies	$[illegible]		$2.[illegible]		
Ratio of total cost to sum of items above given	1.[illegible]		1.1[illegible]		$1.[illegible]
Total estimated cost, including engineering and contingencies		$1.[illegible]		$[illegible]	2.[illegible]
Fair value to use in estimate, to which [illegible] for engineering and contingencies is to be added		[illegible]		[illegible]	2.50

*The contract price at ordinary depths of [illegible], and exclusive of rock, was 70 cts. per lin. ft. The difference, [illegible] cts. per ft., represents the additional allowances for extra depth and for rock and for [illegible], and for all contingencies because of the character of the ground. These additional costs would naturally be somewhat higher on the 26-in. line than on the 24-in. line, and the route of the [illegible]-in. line covers substantially the same ground as that occupied by both the 26-in. and 24-in. lines.

when the cement is usually hard enough to permit of handling them. The pipes are then loaded upon a truck, taken to the yard, cleaned, and painted with a coal-tar paint. After staying in the yard about two weeks they are sufficiently hard to permit of being loaded upon a wagon and carted to the trench.

Tables Nos. I and II show respectively the cost of making and laying the largest cement-lined pipes which have been made at Plymouth. Town labor, only, is used, and $2 is the wage paid for a working day of eight hours, for each laborer. The foreman receives $3.

The pipe-making gang numbers about 16 men, but only 4 are kept on the regular gang and the others are hired as they are needed.

Portland, Me.—In the years 1868-9 the Portland Water Co. laid a 20-in. wrought-iron cement-lined supply main, about 15.2 miles long, from Sebago Lake to the city of Portland. Data as to the cost of this main are unfortunately lacking.

In the years 1875-9, however, a second wrought-iron cement-lined supply main was laid from the lake to the city. The upper portion of this, approxiamtely 3½ miles in length, was 26 ins. in diameter; the lower portion, approximately 11.4 miles in length, 24 ins. diameter. The actual cost of this compound main was fortunately developed from the books of the company and is given in Tables III and IV, as some of the unit costs to be derived therefrom are interesting and valuable.

It should be stated that the static pressures upon this supply main are approximately as follows:

4 miles, under	0— 40 lbs. per sq. in.
2.7 miles, under	40— 60 lbs. per sq. in.
4.9 miles, under	60— 80 lbs. per sq. in.
2.3 miles, under	80—100 lbs. per sq. in.
0.9 miles, under	100—120 lbs. per sq. in.

The main is stated to have been built with a factor of safety of approximately 3, but the computation of the factor of safety under several assumed heads indicates that the actual factor of safety is probably not in excess of 1.5 at the points of maximum pressure, assuming always static pressures, and ignoring alike the decrease in pressure due to friction and the increase in pressure due to water hammer or other causes.

The cost of this 26-in. pipe line was excessive, owing to deep cut work, a considerable amount of which was in quicksand.

Mr. Allen Hazen, who was one of the engineers retained by the Water District in the valuation of the Portland waterworks, made the interesting analysis of these items of cost given in Table V.

On March 2, shovel No. 220, working in the Empire Construction District, Central Division of the Isthmian Canal, removed 3,941 cu. yds. of rock and earth in a working day of eight hours.

Railway Section

Note: This section is devoted to methods and costs of constructing railways. It will cover road-bed and track construction, contractor's plant and organization, surveying methods and permanent way structures.

Report of H. P. Gillette to the Washington Railroad Commission on the Valuation of the Railways in Washington.*

Before explaining the methods pursued in making the appraisal, it is as well to record the fact that the State of Washington is the first state in the Union to complete the valuation of its railways for the express purpose of using these values as a basis for rate making. Only one other State Railway Commission takes priority over the Washington Railroad Commission in point of time of completing a valuation of the railways within the state, namely, the Texas Railway Commission; but it should be remembered that the object of the valuation of the railways of Texas was not for the purpose of rate making, but for the purpose of limiting the issues of stocks and bonds—that is, to prevent "stock watering"—which presents quite a different problem from that presented to the Washington Railroad Commission. Vastly greater interests are at stake when railway values are to be used merely to limit the issue of stocks and bonds of railways chartered within the state. Hence, both the scope of my investigation of railway values, and the methods used were radically different and necessarily much more complex than prevailed in the Texas appraisal. For example, in the following out of the requirements of the Washington statute, you felt impelled to secure all the data enumerated by the Supreme Court of the United States in the celebrated Nebraska rate case known as the *Smythe v. Ames* case. The Supreme Court held in its decision of that case that a rate-making body must consider, among other things:

First. The original cost of the railway, plus improvements and betterments.

Second. Its cost of reproduction new.

Third. Its present value, ascertained by deducting its depreciation from its value new.

Prior to this Washington railway appraisal, no Railway Commission in America had ever attempted to comply with the decision of the Supreme Court in the Nebraska case, and I believe that all the failures on the part of other Railway Commissions in their rate-making efforts may be traced directly to their fundamental failure to follow the Nebraska rate case decision. Flat rate making has proven abortive, because of attempts to make rates without full knowledge of all the factors which the Supreme Court has held to be necessary in forming an intelligent judgment; and prominent among these factors are the original cost, the cost of reproduction, and the present value.

Two other states besides Texas have made railway appraisals, namely Michigan and Wisconsin; but in neither of these instances was the appraisal made by a railroad commission. Both the Michigan and Wisconsin appraisals were made for the purposes of taxation, and were not governed by the Nebraska rate case decision.

The State of Washington is the first state to secure the *original cost* of the railways within its boundaries and is, therefore, the first state to investigate the accounting records of the railways with the object of ascertaining the actual original cost and the cost of improvements and betterments.

I mention this fact not merely for the purpose of putting on record the priority which the Washington Railroad Commission can justly claim in following the law as laid down by the Supreme Court, but for the purpose of making clear the magnitude of the task confronting the commission and its engineers and experts.

Speaking for myself, I found the precedents established by Texas, Michigan and Wisconsin of little value, either in deciding the methods to be pursued in making the appraisals or in estimating the probable cost of the appraisal. I ascertained that the State of Wisconsin had spent about $11 per mile of railway for making the appraisal and the railways themselves had spent an equal sum, making a total of about $22 per mile for the joint work done by the state and by the railways, for they both worked together in making the appraisals. When I started the appraisal of the railways of Washington I believed that the appraisal would cost far less than $11 per mile, and I am glad to say that the cost has actually been not more than $13 a mile, although I regret that it was even as much as that. I had no precedent to guide me in estimating the cost of going through the accounting records of the railways, and I underestimated the time and labor involved in that undertaking. Railway accounting records nearly 40 years old had to be discovered and analyzed. I say "discovered," for the railways themselves did not know the nature of these early records, even if they knew of their very existence, which in many cases they did not.

At this point it may be well to explain that these early records are far from being worthless, as many persons have assumed, for the subsequent improvements and betterments can be added to these original costs, and thus bring the total cash expenditures down to date. This total cash expenditure is a wonderful aid to the engineer in estimating the cost of reproduction. To illustrate by an example, take the actual cost of the item of "Engineering" on the Northern Pacific Railway. Up to June 30, 1906, it has amounted to $2,900,000 for the State of Washington, or about 5 per cent of the total actual cost of construction and betterments. An investigation of this seemingly high percentage disclosed two big items, one being about $300,000 for the exploration surveys in the Cascade mountains. At the time these surveys were made, no maps were in existence, and the railway engineers were compelled to explore the entire Cascade Range from the Canadian boundary south to the Columbia River. To-day, in reproducing the Northern Pacific Railway, no such elaborate exploration is necessary, and, if it were eliminated, the cost of engineering would be reduced to $2,600,000. In like manner certain other items of engineering would be reduced, so that the total cost of engineering should not exceed $2,500,000, which is the sum that I used in estimating the item of engineering when making my estimate of the cost of reproduction. It would take several hundred pages to explain my analysis of the original costs, and my use of the data thus obtained in guiding my judgment as to a proper allowance for the cost of reproduction of each item. I wish, however, to say had I not secured the original costs I am positive that my costs of reproduction would be nothing better than engineering guesses insofar as certain items are concerned. For example, the cost of grading, especially through rough and mountainous country cannot be accurately ascertained to-day by any engineer not possessed of the original records showing the quantities and classification of excavation or of the actual costs of doing the grading work. It is true that in the entire absence of original records of any sort, an engineer can go into the field, and cross-section the existing "cuts" and "fills," and make an estimate of yardage of the different classes of excavation, but I should never do this except as the very last resort, and then with the determination of adding a very large percentage for contingencies.

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*In subsequent issues of Engineering-Contracting the detailed values of the railways will be published.

I may state at this point that one of the most potent reasons for securing the original quantities and original costs is to eliminate the item of "contingencies" entirely. It sounds little enough to speak of 10 per cent added for "contingencies," but it would have meant adding just $5,000,000 to my estimate of the Northern Pacific Railway alone.

Reverting briefly to the cost of appraising the railways of Washington, attention should be called to the lack of logic in estimating the cost of such appraisals in terms of the mile as the unit. The Wisconsin appraisals cost $21 a mile, but the Wisconsin railways have an appraised value of only $30,000 a mile, hence the Wisconsin appraisal cost 70 cts per $1,000 appraised. The Washington appraisal cost $13 a mile, but the Washington railways have an appraised value of $60,000 per mile, hence the Washington appraisal cost 20 cts per $1,000 appraised, as against 70 cts in Wisconsin. There is not the slightest doubt that it costs more per mile to appraise a line worth $60,000 a mile than to appraise one costing $30,000 a mile, if the same methods of appraisal are used; for the $60,000 line contains many more structures and details per mile, and higher land values, involving more labor on the part of both accountants, engineers and right-of-way appraisers. If this is so, it will be asked why the Washington appraisal cost less per mile than the Wisconsin appraisal. An answer leads me into the subject of the methods used in making the Washington appraisal, for upon those methods depends the relative economy.

Methods of Appraisal. Before entering upon the task of appraising the Washington railways I had secured all desired information as to the appraisals of the railways in Texas, Michigan and Wisconsin. I also saw the engineer of the Minnesota Railway and Warehouse Commission, who had been engaged for six months on the appraisal of the Minnesota railways. I found that the Wisconsin and Minnesota methods of appraisal were practically identical. Both states furnished printed blanks to the railways, and required the railways to make a detailed estimate of the cost of their own property. Upon securing such estimates, the states' engineers checked up the appraisal. This method is advocated largely on the ground that it avoids duplicating the expense of an appraisal, the assumption being that each railway itself will make its own appraisal in any event, whether asked to or not. Therefore, if the railway is required to make its own appraisal first, the state's engineer need not go through all the details, but can accept most of the matter after a more or less cursory inspection.

I was wholly dissatisfied with this method, for I felt that it would make it almost imperative for me to accept the appraisals made by the railways, practically at their own figures, or to undertake in the end what I could just as well undertake in the beginning, namely an independent investigation of my own. I need scarcely say that the results of the investigation have served to confirm my position on this point.

Neither the State of Minnesota nor Wisconsin had gone into the matter of the actual cost of the original railway property. This seemed to me a serious omission, not merely because of the Nebraska rate case decision but because of the invaluable data that an investigation of actual costs would disclose.

In estimating the present or depreciated value of structures, rolling stock, etc., both Michigan and Wisconsin had sent experts into the field to estimate the percentage of present value of each car. In this manner 10,000 freight cars were inspected in Michigan and their "present value" estimated. To me this seemed to be not only a useless procedure, but very erroneous. Aside from the great expense of thus inspecting each car and structure, I was influenced by a belief in the far greater accuracy of applying what might be termed "mortality tables of structures." If the age of a man is known, his expectation of life can be estimated from mortality tables. Insurance companies do not have their doctors guess at the man's probable life. The doctor merely reports the man as not suffering from disease, and the insurance company having the man's age, applies its mortality tables. In like manner, it seemed to me, the "present value" of a car or locomotive could be accurately estimated if its present age were known. It is a well-established fact that a freight car has a useful life exceeding 20 or 25 years. If the average car has a life of 25 years, it loses 4 per cent of its life every year. Hence, by multiplying its age in years by 4 per cent, its lost life or depreciation is accurately ascertained; and, by subtracting this depreciation from 100, the remainder will give its "present value," expressed as a percentage of its value new.

I believed that it would be far less expensive to ascertain the age of each car and each structure from the records of the companies, and to estimate the present value by the method just explained, than to inspect each structure in the field. This proved to be the case, and it effected a very substantial saving in the cost of appraisal, while, at the same time, it yielded more reliable results.

In some cases the records in the engineering offices of the railways did not show the ages of existing structures, but in such cases their accounting records showed the dates when structures were built or when cars were purchased.

If practically all the structures shown in the accounting records are still in existence and the money expended each year for each class of structure is known, it is a very simple matter to figure the average age of the money invested in such structures, which, after all, is what is needed in estimating present value. To illustrate, suppose there are a number of station buildings in existence whose age is not known. Suppose, however, that $10,500 was spent for such buildings in 1896, $20,000 in 1900, and $5,000 in 1902. Then, in 1906 the average age of the money invested in these buildings is ascertained thus:

$10,500 × 10 yrs equals $105,000 one year
$20,000 × 6 yrs equals $120,000 one year
$5,000 × 4 yrs equals $20,000 one year

$35,500 × 7 yrs equals $248,500 one year

This gives a total of $35,500 invested 7 years, for $35,500 × 7 years equals $248,500 one year.

The rule to be followed in all such cases is to multiply the money expended each year for structures of a given class by the age in years, add all these products together, and divide by the total cost of all the structures under consideration. The quotient is the average age of all the structures, or, more strictly speaking, the average age of the money invested in the structures. If some of the structures are no longer in existence, this method can still be applied. Take railway cross-ties, for example. Ascertain the total value of cross-ties in the track, then go back through the records of cost and tie renewals, by years, until the total cost of the renewals adds up to the total value of ties now in the track. Then compute the average age as above shown. If the price of ties has fluctuated, ascertain the actual price paid, and reduce all yearly expenditures of renewals to the present price.

It will be as impossible, as well as undesirable, in a report of this character, for me to indicate all the methods pursued in the appraisal of railways, but some of the radical departures from precedent should be outlined, particularly where a result is secured in more thorough or in a more economic manner. Moreover, any chief engineer who may be in your employ in the future will be greatly handicapped without an outline of the methods pursued in this original appraisal.

In searching the records of the railways, I did not confine myself merely to their engineering and their accounting books, but often found missing links of information in the most incongruous places. The Oregon Railroad & Navigation Company, for example, had practically none of its "construction ledgers," and at first we despaired of being able to piece together a complete itemized summary of original cost. Finally we found an old tissue copy book, Book No. 51, at the Ash St. Dock in Portland, containing copies of the auditor's distribution sheets, showing costs of engineering, grading, etc., etc.

For several months our work was considerably retarded, not only by the reluctance of several of the railway companies to assist us in finding their records, but by the incompleteness of the records when found. Little by little, however, we were able to fill in the gaps, until there remained not 10 per cent of the original unascertained.

For the guidance of any engineers whom you may employ in the future, I give a list of the most important records to be looked for in making an appraisal of this character.

1. Annual reports to stockholders.
2. Annual reports to Interstate Commerce Commission.
3. Annual report of chief engineers and superintendents to the president of the road.
4. Reports of minor officials.
5. Progress profiles.
6. Cross-section and quantity books.
7. Final estimates on contract work.
8. Tissue copy books of final estimates.
9. Rail and ballast charts.
10. Bridge books (engineering department).
11. Building books.
12. Work orders.
13. A. F. E.'s (authorization for expenditure).
14. Accounting records (a) Construction Ledgers, (b) General Ledgers and their accompanying journals, (c) Vouchers, Registers, (d) Vouchers, (e) Auditor's Distribution Sheets, and the like.
15. Equipment Registers.
16. Distribution Book, or Disbursement Accounts Books, containing directions for accountants to follow.
17. Confidential Reports.

In my judgment the first step to be taken in appraising a railway is to ascertain its physical and financial history. For this purpose the annual reports to stockholders are an invaluable source of information. By a perusal of these reports an historical map or chart can be prepared showing the limits of each "construction division" or branch of the railway, and the dates of beginning and completing the construction work on it. The present "operating divisions" often have the same names as certain "construction divisions" of the road, but wholly different limits. Hence the necessity of an historical map in order to avoid confusion in interpreting the accounting records of the road.

Having prepared a map, and a brief history of the road, the next step should be an investigation of the accounting department records. The tendency of a civil engineer is to go to the engineering records first, but this is a mistake, for the accounting records are usually kept in a much better shape, and contain fewer gaps. From the construction ledgers, an itemized account of the original cost of each construction division is secured, and having been secured, the next step is to check it by the records of the engineering department, where quantity books and tissue copy books of final estimates paid to contractors, and the like, are usually to be found. Frequently, however, it happens that a line has been purchased, and that only the engineering records were transferred at the time of the purchase. In which event it may be impossible to secure the accounting records, except by going to the original owners of the property.

Having gone rapidly through all the accounting and engineering records to ascertain what gaps, if any, exist as to original construction data, the next step is to put engineers into the field to supply the missing links by actual inspection, measurement, etc. An attempt to estimate by field survey should be the last resort, not only on account of the greater cost of field work, but because of its greater inaccuracy, and finally—but not to be ignored—because, in case of a legal dispute as to the estimated cost, field surveys, and estimates made by different engineers are likely to differ widely. There is always so much that cannot be seen, like the foundation of bridges, the percentage of loose rocks in embankments, etc., that a field survey should be used only as a last resort. And, in our appraisal of the Washington railways, field surveys were made only for a very small percentage of the total mileage.

A field inspection of every mile of track should be made, preferably by an engineer riding on a handcar. This engineer should be provided with complete, up-to-date profiles, and small scale plans of the road, showing all structures and their dimensions, etc. I made the mistake of accepting the existing profiles and plans for use by the field inspectors. These records were so often incorrect, through not having been kept up to date, as to cause much unnecessary work subsequently in checking. Haste in sending out field inspectors is a mistake, as field inspection of this sort is the most inexpensive item of an appraisal, and can be quickly done even with a comparatively small force. One man on foot will inventory about 12 miles of ordinary track each day, or twice that amount on a handcar. Field inspection, therefore, should not be begun until corrected up to date profiles and maps have been prepared, and until the investigation of the engineering records has been carried far enough to disclose the particular structures upon which the office records are incomplete. By doing this, the field inspection resolves itself into a checking off of structures with an occasional pause to measure some structure on which the office records are defective.

The appraisals heretofore made in other states have been based almost entirely upon field surveys and inspection, no attempt having been made to secure the necessary data from the engineering and accounting records of the railways. Why? The answer is found in the *purpose* of the appraisal. As previously stated, the *purpose* of the appraisals in Texas, Michigan and Wisconsin was not the same *purpose* as in Washington. Where the *purpose* is taxation, a railway naturally seeks a low valuation for its property, hence it prefers to refuse access to its own records, believing —and believing rightly—that what cannot be seen with the eyes will not be likely to appear in the appraisal. An appraisal by field examination solely is very apt to be below the true value of the property, hence the acceptability of such an appraisal by the railways where taxation is the *purpose* of the appraisal.

Several of the principal railway systems in Washington at first resisted our efforts to secure the records in their offices, and stated that the records were so incomplete as to be valueless. In some instances I have no doubt that this was an honest opinion. I am inclined to believe, however, that their motive in resisting an examination of the records was, in some cases at least, to secure an appraisal which could be fought in the courts, and probably upset by documentary evidence to prove its unreliability in parts, if not in its entirety. Therefore I hold to the belief that an investigation of both the accounting and engineering records of the railways would have been the best policy, even had it cost many times what it did cost. And to show my reason for this belief I will cite just one example. In testifying before your honorable body, Mr. Hogeland, chief engineer of the Great Northern Railway, has estimated the cost of earth excavation to be made up of three different items, as follows:

Average contract price, up to 1,000 ft. haul	$0.230 per cu. yd.
Average overhaul	$0.035 per cu. yd.
Transportation of men's tools, supplies	0.045 per cu. yd.
Total	$0.310 per cu. yd.

Had we not secured the actual records in the Great Northern offices, it might have been a difficult matter to convince the court that the last two items of the above estimate are ridiculously high. Having the records, it will not be so difficult. For example, the actual cost of the item of "average overhaul" was just one-seventh of Mr. Hogeland's estimate, or one-half per cent per cubic yard, as shown in my statement of the actual cost of construction of the Great Northern Railway in the State of Washington. The item of transportation of men was similarly overestimated.

I will not enter into such details further, but, in justice to myself and you, I feel it my duty to explain *why a departure from precedent in railway appraisal was the best policy*. Such an illustration as the above will serve better than many generalities to show the character of the reasons for our exhaustive investigations into the original cost of the railways of this state. Were you, as a court, or were any other court, confronted by the conflicting testimony of expert engineers, it would be difficult to arrive at a just opinion as to proper quantities and prices, unless the actual data were available to guide you. The data are available and are now in your possession.

I have not touched upon the very important matter of the appraisal of the rolling stock, or equipment, further than to say that I did not make a field inspection of it. The office records were so complete that such an inspection was superfluous, and for the reason above given. In order to apportion to the State of Washington its share of the cost of the rolling stock, it was necessary to appraise the entire equipment of every railway system entering the state. This, in itself, is no slight task. Several states should share the cost of appraising the equipment of the railways, so that the whole cost would not fall on one state, as in this instance.

If Washington, Idaho, Montana, the Dakotas and Minnesota could have acted in concert, the cost of railway appraisal would have been very much less, not only because of the distribution of the cost of appraising the equipment, but because of the rapidity with which an entire railway system can be appraised once an engineer becomes familiar with the accounting and engineering records of that railway system. For this reason, as well as for others, the railroad commissioners of certain groups of states should strive to get together.

The appraisal of right of way lands and station grounds, as far as present value goes, was delegated principally to three right of way experts, men who had been buying lands for railway purposes in Washington and were familiar with prices. Your honorable body adopted a method of arriving at land values which was entirely novel and, to my mind, a vast improvement over any other method hitherto used in other states. The method consists in calling in real estate men in all the large cities, and securing testimony from those men as to land values. Your honorable body, sitting as a court, hears the testimony not only of the regularly employed right-of-way experts, but of expert real estate witnesses, which those right-of-way experts have consulted, and other real estate experts which the railways may bring in. Hitherto the practice has been to examine all real estate transfers within a certain distance of the railway property, and for a period of years prior to the appraisal, and to base the appraisal upon these transfers. Since property for railway purposes usually costs more than for other purposes, it is necessary to multiply the value ascertained from transfers of adjacent property by some factor, this factor being ascertained from expert testimony or otherwise. Unfortunately the records of the real estate transfers are not the best evidence of the value of the property transferred. Indeed the records are often made so as to *conceal* the real value of the property. For this reason alone the method devised by your honorable body is much to be preferred. Moreover, it is a less expensive method of appraising lands.

As to my methods of appraisal I need say little more. My testimony before your honorable body is complete on those matters, but, being of great length, I have thought it wise to summarize certain features in this report, giving also a few suggestions, which may assist any engineer who may be in the employ of the Washington Railroad Commission in future.

It is needless to tell you, but for the sake of public record I desire to say that on all the smaller railways in Washington I was given most courteous treatment, and had ready access to all records. On the three large systems, namely the Great Northern, the Northern Pacific and the Oregon Railway & Navigation Company, I met with much resistance at first and lost several months of time in consequence. Denial as to the existence of certain important records was repeatedly made, records that I subsequently found. Possibly these denials were made in good faith, but since free access to all records was not given me by the Great Northern and the Northern Pacific for a long time, and then only after I pieced together enough information to prove the existence of the records, my work was greatly prolonged. I think that these railways [illegible] see that it was an error not to put all records at my disposal [illegible]. I regret it that they were not prompt in rendering that assistance. I regret it not only on account of the increased cost of the appraisal, but because I had business duties in New York that made my return imperative at as early a date as possible.

In conclusion I wish to express my hearty appreciation of the loyalty and zeal with which my assistants worked. Those in the most important positions worked not only by day but by night. I know of no one who seemed swayed by the fear of "working himself out of a job." My two principal assistants, Mr. Francis W. Collins and Mr. H. L. Gray, deserve special recognition in this report, for upon them fell the brunt of the task. Mr. Collins was located in St. Paul, at the offices of the Great Northern and the Northern Pacific railways, with a corps of men under his direction. Mr. Gray was located in Portland, in the offices of the Oregon Railway & Navigation Company, with a similar corps.

To your honorable body I wish to express my sincere thanks for the many valuable suggestions that came from you as to the conduct of my appraisal. I wish it were possible for me to convey to the people of Washington my unbiased opinion of your honorable body. As a non-resident my opinion is unbiased. I believe you have shown great wisdom in not allowing yourselves to be hurried into action for the sake of being able to point to "results." No ordinary citizen can realize the magnitude and the intricacy of the problem before you. It can become appalling only to one who has come face to face with it and has delved into its details. So far as I know, you are the first state railway commission in America that has not allowed itself to be drawn into active rate making before securing the fundamental facts that should govern such action. One of these fundamental facts is the physical value of the railways in the state. A physical valuation is absolutely essential, if for no other purpose than to determine a reasonable amount to set aside annually from earnings to cover the depreciation from natural agencies and from wear and tear. Tell me the physical value of a given structure, and I can estimate its depreciation in dollars. Conceal that value, and I am utterly in the dark. It has become the fashion to "pooh-pooh" the necessity of a physical valuation of railways by commissions having rate-making powers. Even had the Supreme Court not ruled as to the necessity of a physical valuation, that necessity would exist, if for no other reason than to solve the important problem of annual depreciation.

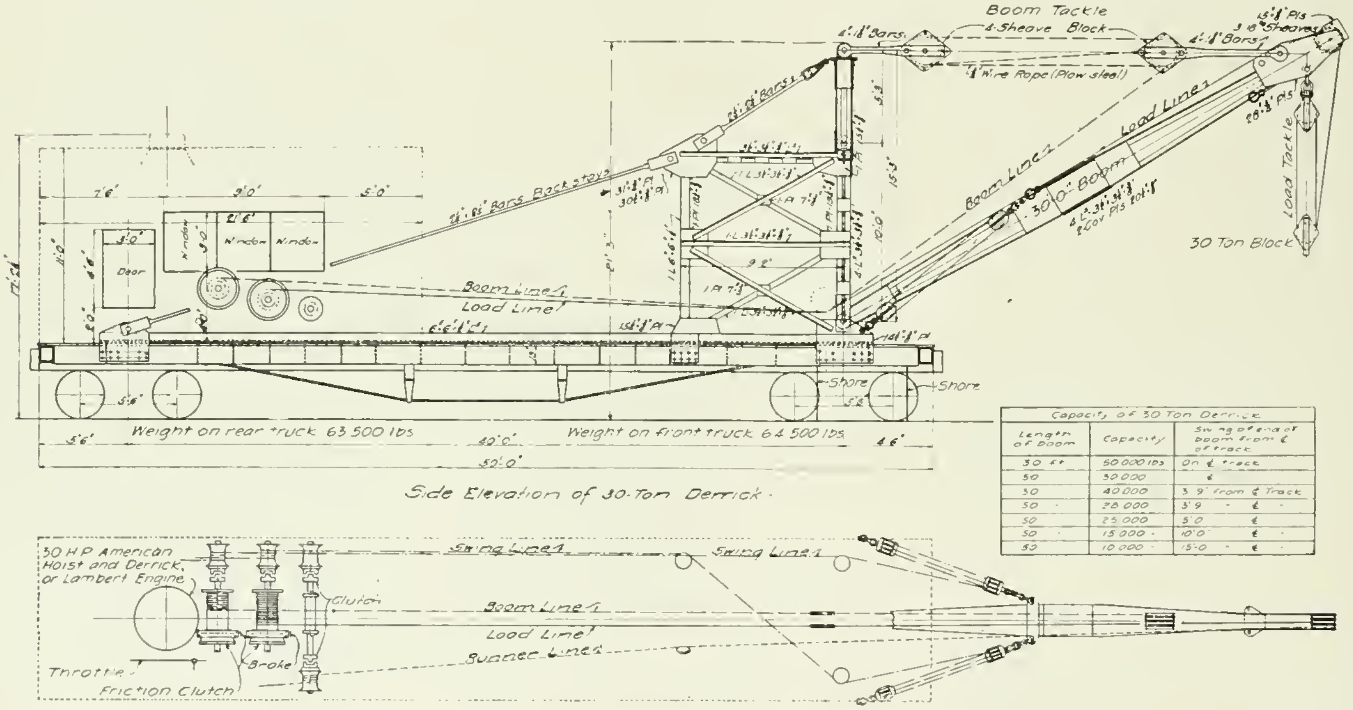
Bridges, Buildings and Foundations

Note: This section is devoted to methods and costs of constructing steel and masonry bridges and buildings and of foundation work of all kinds. It will give special attention to erection plant and tools, falseworks and centers and cost data of all kinds.

Derrick Cars and Methods of Using Them in Bridge Erection on the Chicago, Milwaukee & St. Paul Ry.*

Design of 30-Ton Derrick Car.—Most of the features of the car, designed by W. F. Rech, are shown by Fig. 1, which shows a 15-ft. 3-in. mast, a 30-ft. boom, some 2¼-in.x2¼-in. bars for the backstays, together with the engine and rigging mounted on a 50-ft. flat car of heavy construction. The principal requirements of a derrick car are:

(1) Length of boom reach, with necessary stability of the car.



Capacity of 30 Ton Derrick

Length of Boom	Capacity	Swing of end of boom from ℄ of track
30 ft	50 000 lbs	On ℄ track
50	30 000	℄
30	40 000	3 9" from ℄ Track
50	28 000	3' 9 " ℄ "
50	25 000	5' 0 ℄
50	15 000	10' 0" ℄ "
50	10 000	15' 0 " ℄ "

Fig. 1—Details of 30-Ton Derrick Car for Bridge Erection.

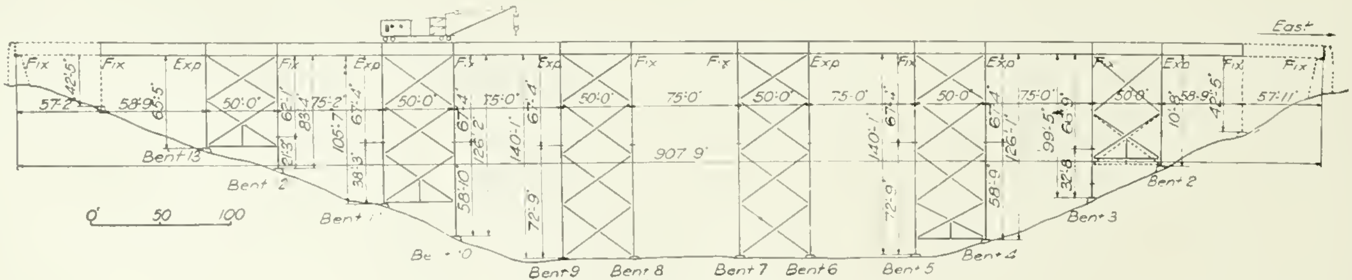


Fig. 2—Diagram Elevation of Peedee Viaduct.

(2) Strength of parts, with the required lightness for handling.

The number of uses to which a derrick car can be put is almost in proportion to its length of boom.

The longer the boom and the greater its capacity, the greater must be the longitudinal and lateral stability of the car. The longitudinal stability (parallel with the track) is comparatively easily obtained by increasing the length of the car, in this case to 50 ft., and by adding the counterweight required, to the weight of the engine and rigging already in place.

Lateral stability is, however, a difficult matter to provide and is a more doubtful quantity than any other feature of the car; this is due mostly to the fact that the width of base of the car available against overturning is limited to the distance c. to c. of rails, unless outriggers or guys are used. The lateral overturning moment of the load is measured by the product of the load into its distance from the nearest rail, and this overturning is resisted by a moment which is the product of the weight of the car into one-half the distance between the rails.

As this half distance between the rails, or the lever-arm of lateral moment of resistance, is only about 30 ins., it is apparent that the capacity of the car for lifts at any distance from the center line of track is limited. The exact figures are given in the table, Fig. 1.

To reduce the stresses in the boom tackle and its consequent weight, it is desirable to make the height of the tower as great as possible, but the permissible height of the tower is limited by the clear head room in through truss bridges and under telegraph wires, during transit and also when the car is at work.

In the design shown, the top of the tower is 21 ft. 3 ins. above top of rail, and it can be seen that the design of the connection at the top of the tower makes practically all of this height effective.

The upper part of the tower consists of

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*Extracted from a paper by J. H. Prior, read before the Western Society of Engineers on March 3, 1909.

an A frame which can be removed when the car is in transit, thus bringing the total height of the car well within the overhead clearances of any railroad.

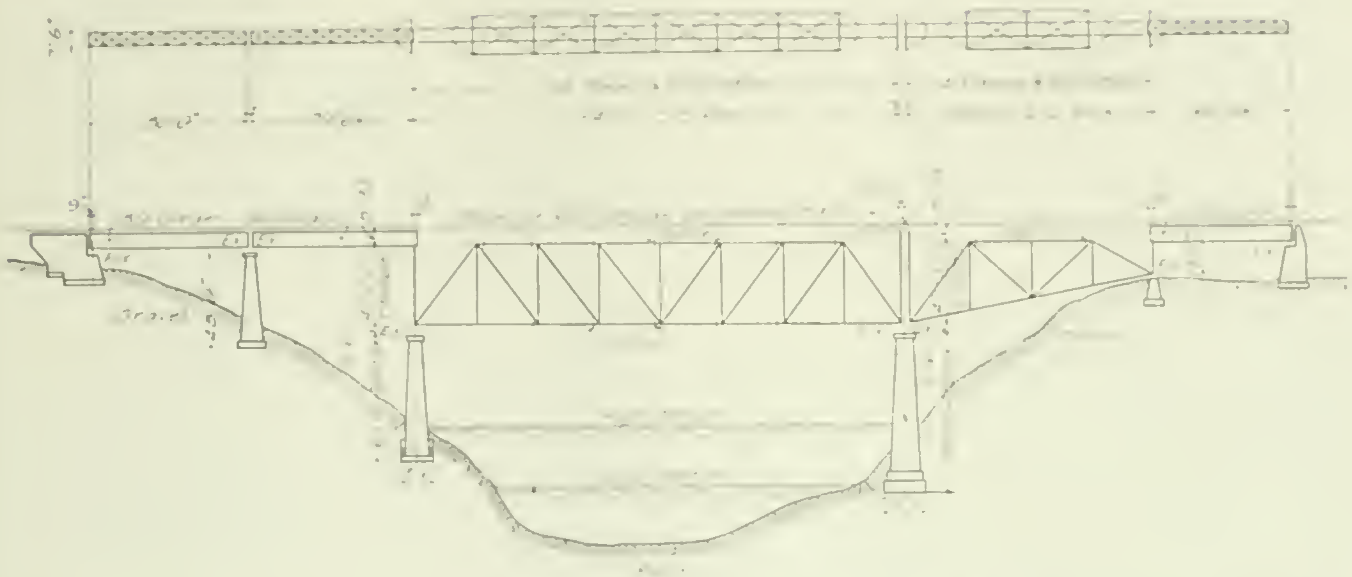


Fig. 3—Plans and Elevation of Bridge Across Missoula River.

The square tower is fully rigged so that when the A frame is removed the car can be used for all purposes but, as the stresses in the top tackle are increased, the capacity of the car is reduced.

The shortest boom is made of two 15 ft. sections; additional intermediate sections of 20 ft. and 35 ft. are provided, making lengths of boom of 30 ft., 50 ft., 65 ft., or 85 ft. available.

When heavy loads are being lifted, there is a provision for the insertion of a tight fitting hard wood block between the body bolster of the car and the side frame of the truck. This permits part of the load to be transmitted directly from the car body bolster to the truck side frame and relieves the side bearings and springs of whatever load passes through the hard wood block.

Fig. 1 shows the arrangement of lines, also of the clutches, brakes and throttle under the control of the engineer. These features are shown in diagram only and the cut does not represent the actual construction of the engine. All winch heads and drums shown are also provided with a rachet and pawl, not shown in the diagram.

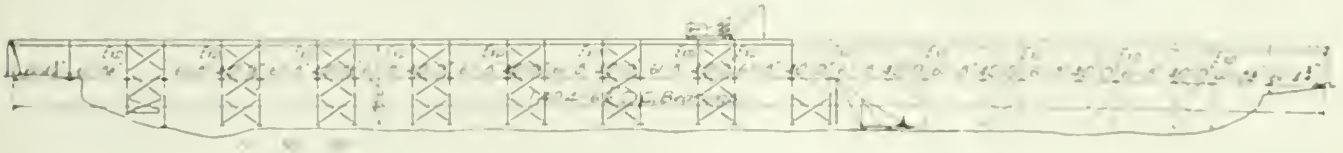


Fig. 4—Elevation of Cow Creek Viaduct.

This diagram shows a 30 HP engine, of a type extensively used in bridge erection. The chief characteristic of this type (which is common to the different makes) is that all shafts, together with all gear wheels attached to same are caused to revolve whenever steam is admitted to the cylinder. The drums run loose upon their shafts and can be made to revolve with the shafts, upon which they are carried, by means of friction clutches. When the friction clutch is disengaged, the drum can be held without motion by means of the brake or the rachet and pawl, the shaft, in the meantime, revolving for the purpose of handling other lines.

The winch heads are also loose upon their shafts, but may be fixed to the shafts by the jaw clutches shown, or, when the jaw clutches are disengaged, the winch heads may be held in one position by means of rachets at their ends and pawls connected to the frame of the engine. When the winch head is held against motion by the pawl, it may be used for fastening the line or holding the load, although the shaft upon which it is carried may be revolving while the engine is handling other lines.

With 110 lbs. of steam pressure, the engine can exert a pull of about 5,000 lbs. on a line fastened to the drum. As this 5,000 lbs. is exerted at a radius of 8 ins. from the center of the shaft, a considerably greater pull can be exerted by the winch head, which has a somewhat smaller radius.

As shown in Fig. 1, each swinging line and runner line after passing from the front of the car is given a number of wraps around the winch head and then passes into the hands of the winch head man. The pull, which the winch head exerts upon the line depends upon the number of wraps which the line makes around the winch head, and also upon the pull exerted by the winch head man upon the end of the line. A very light pull, with only a few wraps around the winch head, permits the winch head to slip and revolve within the line which is wrapped around it, a greater pull and more wraps causes the winch head to grip the line with a force which can be increased up to the breaking strength of the line. The boom line and the load line are fastened to the drum, but before commencing operations, it is usual to take a few wraps around the drum, in order to reduce the stress where the line is fastened to the drum.

On this engine, one engineer controls the throttle, in addition to operating the two friction drums. One winch head man operates the two swinging lines and a second winch head man operates the runner line when it is in use. This makes a total of three men in the cab, the engineer doing his own firing.

The car can propel itself with its own power in either direction by means of a chain wheel which carries a 1½ in. chain which passes around and drives a sprocket wheel keyed to the forward axle of the rear truck. The chain wheel is driven as follows:

A gear wheel is placed on each end of the front shaft, Fig. 1. The gear wheel at one end of the shaft is connected by a train of gears with the chain wheel, so as to make it revolve in the direction which the engine is running and the gear wheel at the other end of the shaft is connected by a similar train of gears so as to make the chain wheel revolve in the reverse direction. The gears at the ends of the shaft run loose and can each be thrown into service (the other gear running idle) by means of a jaw clutch, feathered to the middle of the shaft. This arrangement permits the car to be propelled in either direction by a non reversible engine.

Some Uses of 30-Ton Car.—On a structure such as the Peedee viaduct, shown in Fig. 2, where the material must be brought out on the track and where false work cannot be economically used, a boom of 80 ft. reach would be required to place a single bent ahead of the portion of the structure already erected. The same result can be accomplished with a shorter boom, though not so conveniently, by outhauling the member beyond the reach of the boom.

At the third crossing of the Missoula river, shown in outline in Fig. 3, there is a 240 ft. span crossing a torrential mountain stream. The bottom of this stream is bare rock and does not afford the anchorage which false work would require to resist the force of the current. This made it necessary to design the span so it could be erected as a cantilever; the joints being arranged as shown in the figure, the structure would be rendered self-support-

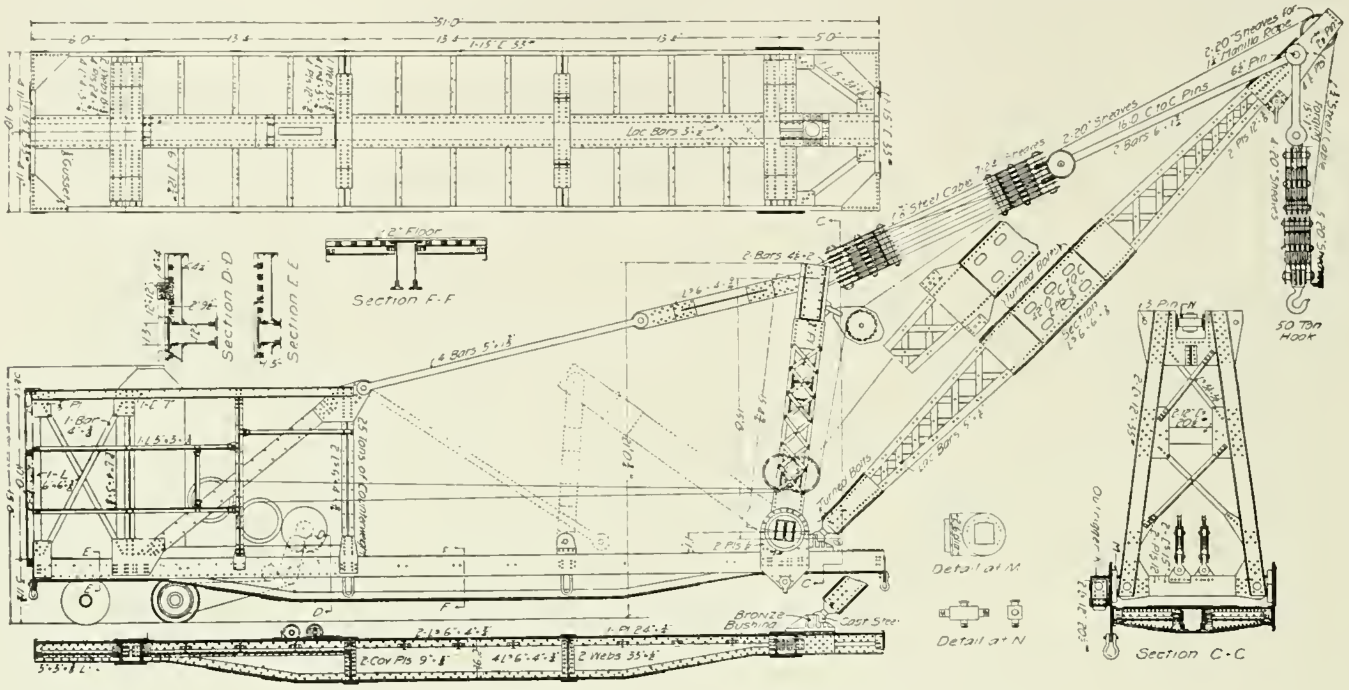
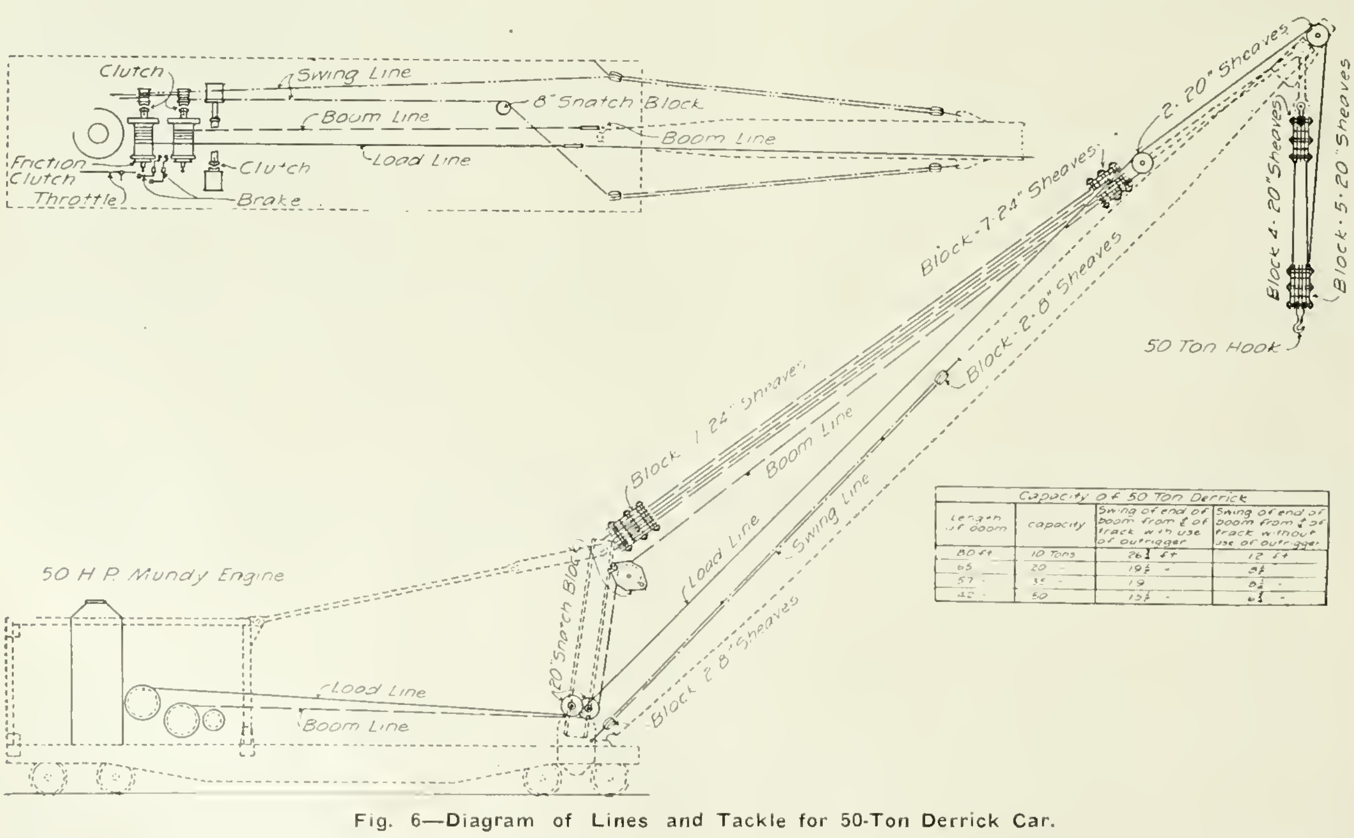


Fig. 5—Details of 50-Ton Steel Derrick Car for Bridge Erection.



Capacity of 50 Ton Derrick

Length of boom	capacity	Swing of end of boom from ℄ of track with use of outrigger	Swing of end of boom from ℄ of track without use of outrigger
80 ft	10 Tons	26½ ft	12 ft
65	20 "	19½ "	8½
57 "	35 "	19	8½ "
42 "	50	15½ "	6½ "

Fig. 6—Diagram of Lines and Tackle for 50-Ton Derrick Car.

ing with the completion of each connection.

The spans between towers of Cow creek viaduct, Fig. 4, are 61 ft. 8 ins. In order to place a tower bent ahead of the completed portion of the structure without

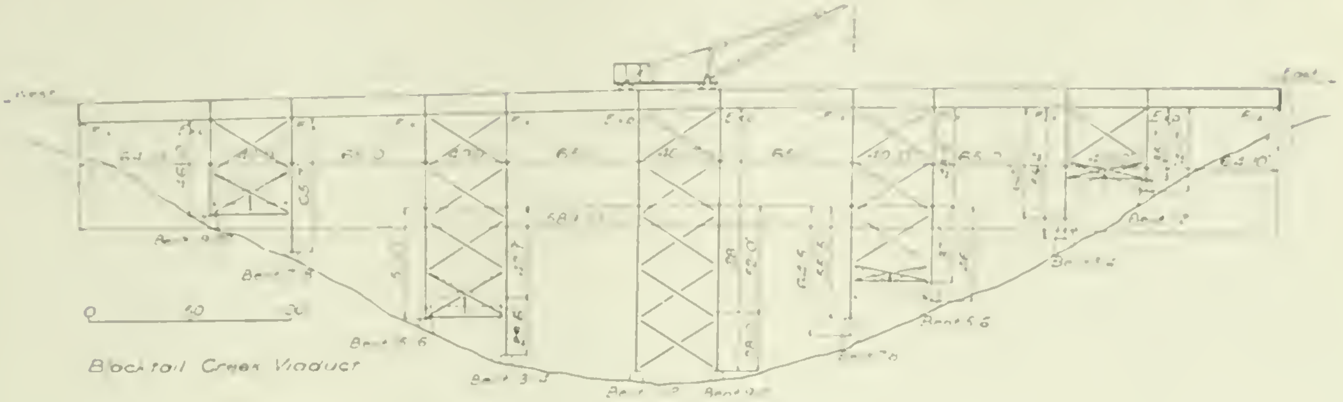


Fig. 7—Elevation of Blacktail Creek Viaduct.

outhauling, a boom of 66 ft. 8 ins. reach would be required. These bents, however, were placed with the 65 ft. boom available, the small amount of outhauling being done with hand lines. The material for this viaduct was brought out to the point where it was required on a small tramway running on the ground along the center line of

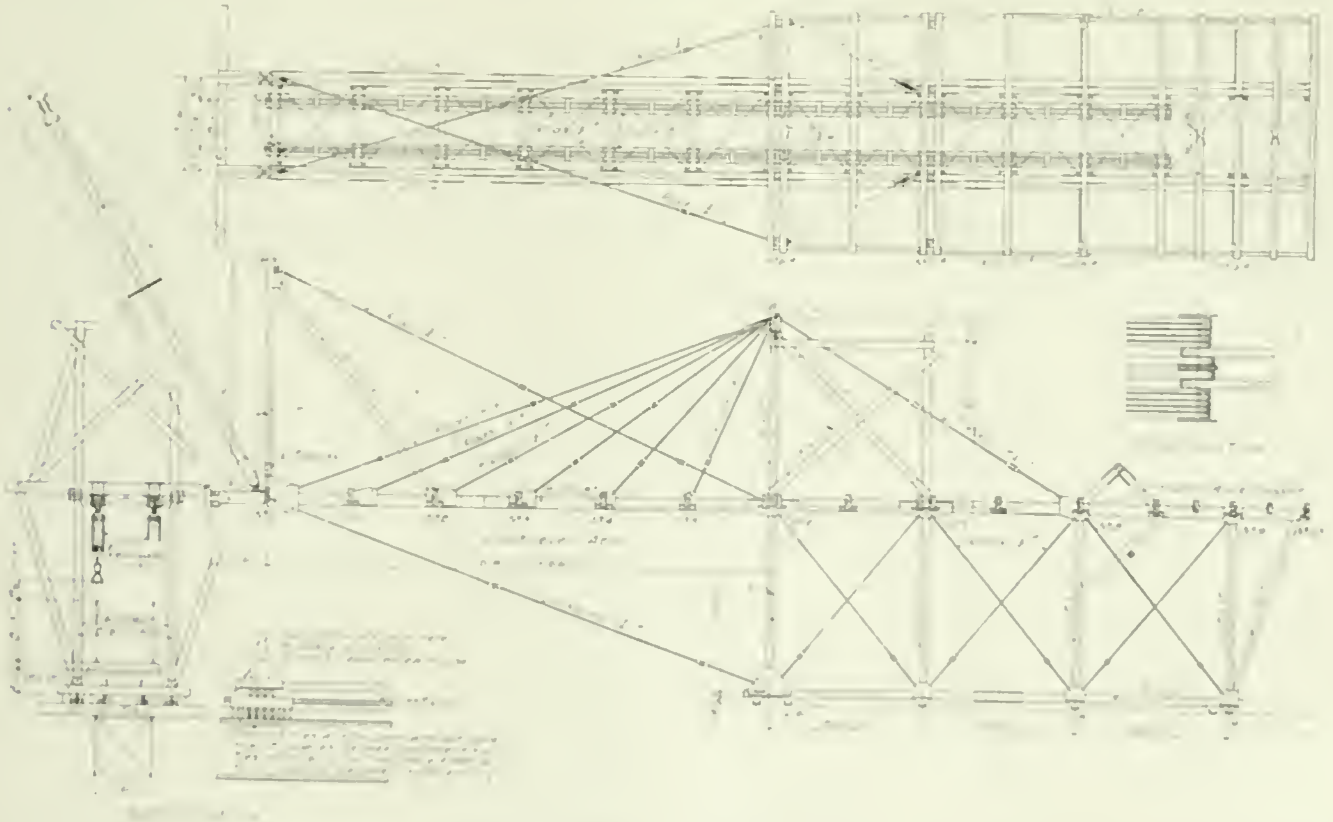


Fig. 8—Traveler for Bridge Erection.

viaduct the material being delivered to the tramway from the track above by a wrecking crane, which happened to be available. This method differs from that used at Pee dee viaduct, where all material was delivered above and carried to its position suspended from the boom of the derrick car. This method of bringing out the material on a tramway was made possible by the level bottom of the valley which the viaduct crosses.

The lower story of the tower was erected by a mule traveler, running on a wide gage track and moving continuously away from the portion of the structure erected. This arrangement, which kept the derrick car continuously supplied with material without moving from its position at the end of the completed portion, greatly increased the erection speed. This viaduct, as shown in Fig. 1, consists of 27 spans supported by 12 towers, and was erected by the company forces in 18 consecutive days.

Design of 50-Ton Derrick Car.—Figure 5 shows the general features of the 50-ton derrick car designed by W. A. Drake. The principal requirements of design and the difficulties encountered in satisfying them, as given in the description of the 35-ton car, are equally true as applied to the 50-ton car. But in this case the essentials of reach, stability, etc., were provided in a somewhat different manner.

The longitudinal stability of the car was increased by the addition of 25 tons of counter weight, and its lateral stability by the use of outriggers.

Figure 5 shows this car to consist of a steel superstructure mounted on a steel flat car. The A-frame which performs the work of a mast is riveted to two transverse channels which are fitted to the two circular castings M, which in turn rest on the plates which are riveted to the sides of the car. The channels form a box into which the I-beam outrigger telescopes when not in use and from which it can be withdrawn, when required, to either side of the car, depending upon the point from which the load is to be lifted. The outer end of the outrigger rests on blocking or a jack, bearing against the ground.

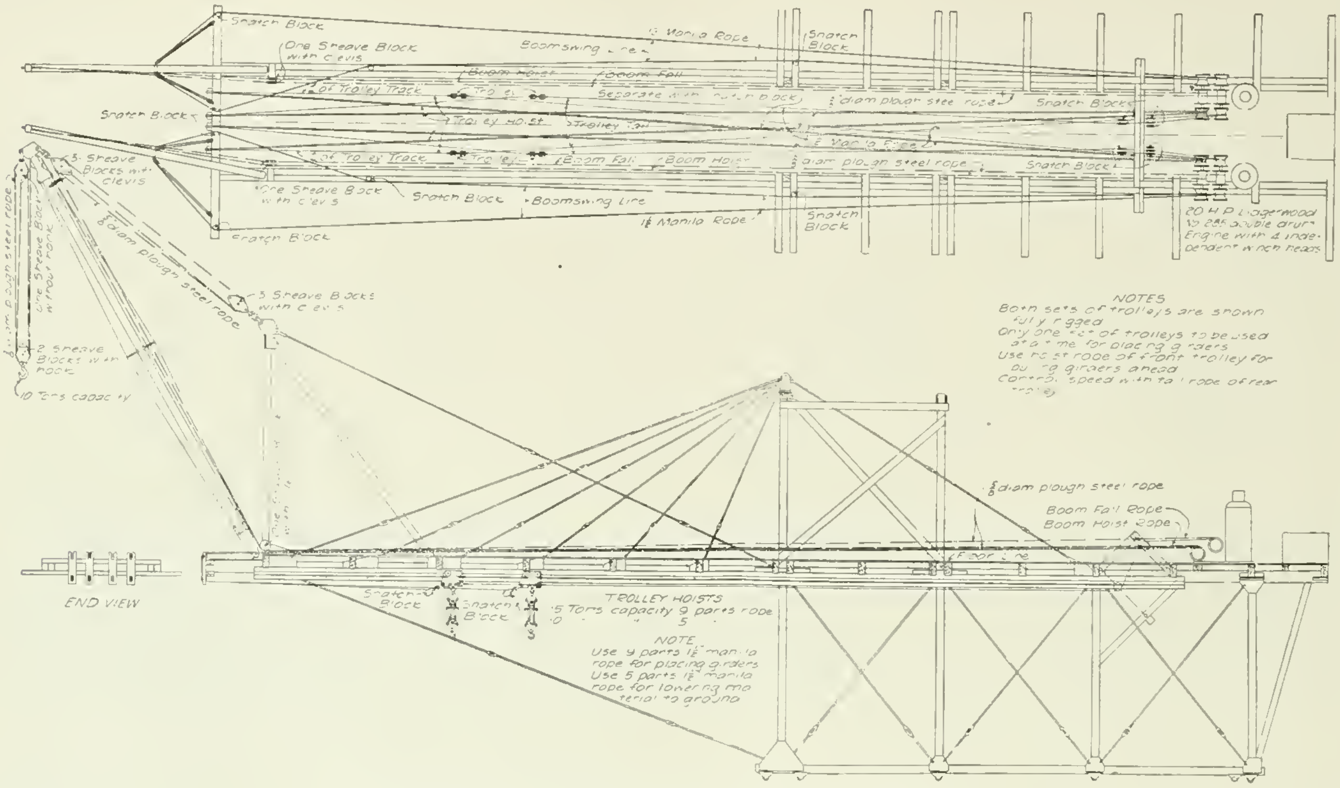

Snatch Block
One Sheave Block with Clevis
Boomswing Line
¾ Manila Rope
Snatch Block
Boom Hoist
Boom Fall
of Trolley Track
Trolley
Separate with Snatch Block
diam plough steel rope
Snatch Blocks
Snatch Block
Trolley Hoist
Trolley Tail
Manila Rope
3 Sheave Blocks with Clevis
of Trolley Track
Trolley
Boom Fall
Boom Hoist
diam plough steel rope
Snatch Block
One Sheave Block with Clevis
Snatch Block
Boomswing Line
1½ Manila Rope
Snatch Block
Snatch Block
20 H P Lidgerwood 10 x 12 double drum Engine with 4 independent winch heads
diam plough steel rope
One Sheave Block without hook
diam plough steel rope
3 Sheave Blocks with Clevis
2 Sheave Blocks with hook
10 Tons capacity
NOTES
Both sets of trolleys are shown fully rigged
Only one set of trolleys to be used at a time for placing girders
Use hoist rope of front trolley for pulling girders ahead
Control speed with tail rope of rear trolley
⅝ diam plough steel rope
Boom Fall Rope
Boom Hoist Rope
Floor Line
END VIEW
Snatch Block
Snatch Block
TROLLEY HOISTS
15 Tons capacity 9 parts rope
10 " " 5 "
NOTE
Use 9 parts 1½" manila rope for placing girders
Use 5 parts 1½" manila rope for lowering material to ground

Fig. 9—Diagram of Lines and Tackle for Traveler.

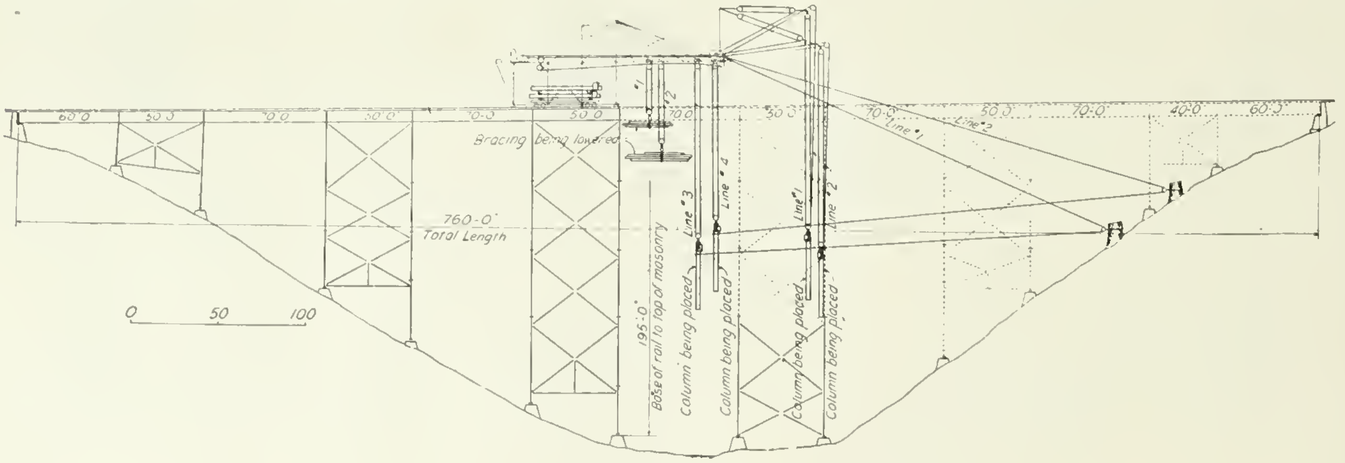


Fig. 10—Elevation of Clear Creek Viaduct.

To reduce the stress in the boom tackle, the A-frame is made as high as possible, being as shown, 21 ft. ¾ ins. over all above the top of rail. This height is within available clear headroom, but can be materially reduced by revolving the A-frame backwards around the casting *M* (as shown in dotted lines) when the car is in transit.

At the top of the A-frame is a forging revolving on its horizontal axis and having bearings for its ends in the A-frame and back stays. A vertical pin passes through this forging. To this vertical pin are attached two short eye bars, which are also attached to the lower block of the top tackle. The backstays, as mentioned, are also connected to this forging, which is about as central a connection as can be obtained in a derrick car.

The boom is in sections and has a maximum length of 80 ft. when assembled. By the removal and substitution of intermediate sections, this length can be reduced to 65 ft., 57 ft. or 42 ft. The thrust of the boom at the bottom is transmitted by a casting terminating in a spherical surface, to a bronze bushed socket forming a ball and socket joint. The 16 ft. bars shown at the end of the boom tackle are necessary to keep same clear of the boom when using long booms at high elevation. The capacities of the boom in various positions are shown in the table in Fig 6. In spite of instructions, greater loads than these have often been lifted in service.

In Fig. 6 is shown the arrangement of lines on the car, also a diagram of the clutches, brakes, etc., but not the actual construction of the car.

The engine and propelling device on this car are of the same type as described under the 30-ton car and are operated in a similar manner, except that the engine is 50 hp.

This car is equipped with a large locomotive air compressor. With a boiler pressure of 110 lbs., this compressor, with the assistance of two storage tanks located underneath the car floor, will supply sufficient air at 100 lbs. pressure for the operation of five riveting hammers.

This compressor also furnishes the air for operation of the car air brakes; the presence of an air brake on the car puts the movement of the car as thoroughly under the control of the engineer as it is when the car is handled by a locomotive, and this has proven a valuable safeguard when moving the car towards the end of the track on the completed portions of high structures, often on a falling grade.

The car cab has a rolling lift front door and a folding side door, which affords ample view for the engineer and wide openings for exit in case of accident.

The two cars have been employed for over a year, often for duties beyond their rated capacities, and have given satisfaction to the field forces of the department.

The Blacktail creek viaduct, shown in Fig. 7, has intermediate spans of 65 ft. A tower bent could be placed with the 80 ft. boom, the great length of this boom making it possible to do all this work without outhauling.

Traveler for Viaducts.—For structures like the Tekoa viaduct, where it was necessary to erect the viaduct on a new line before the track had arrived at that point, and for high structures like the Clear Creek viaduct, where erection had to be hurried to completion before an approaching winter in a country noted for heavy snow falls, it was necessary to design an erection machine with a capacity for the continuous and economical employment of a larger working force than would be possible with the derrick cars, the increase in working force to result in proportional increase in tonnage erected per day.

Such a device is the traveler, designed by H. C. Lotholz, shown in general plan, Fig. 8, and with a diagram of lines in Fig. 9.

It was the intention to use this traveler at three other viaducts and so further distribute its cost, but this was prevented by some delay in the completion of a heavy rock cut, where the traveler was to be erected, and by other circumstances beyond the department's control.

The illustrations of this machine (Figs. 8 and 9) show a combination structure of wood and iron, which spans the track, thereby permitting material to be brought to the traveler on flat cars as far as L 6, Fig. 8, and which also permits the passage of trains through the traveler immediately after completion of the structure.

This traveler has a cantilever arm of 75 ft. and two 60 ft. wooden booms, making a total reach of about 120 ft. As shown on Fig. 10, this reach makes it possible to erect an entire tower in advance of the completed portion of the structure, the tower being stable in itself without the use of temporary braces.

The cantilever arm is equipped with four trolleys, each of 15 tons capacity. Each trolley is composed of a steel carriage on rollers, from which are suspended two 4-sheave blocks, rove up with nine parts of 1½ in. rope.

A hook of 10 tons capacity was hung from each boom and 30 tons of rail for counter weight were placed at the rear end of the traveler. Additional anchorage was provided by anchoring the traveler to the girder with hooks. The traveler was also anchored sideways by means of three ⅝ in. hoisting cable guys, on each side, attached to the top of the traveler. The engines are of the same general type as described under the 30 ton derrick car, except that the front shaft is omitted and the horsepower is somewhat less.

The following is a rough description of the operation of the traveler and as both sides of the traveler are alike, only one side will be described.

First. The 10 ton hook at the end of the boom is suspended from a four part tackle of ⅝ in. hoisting cable, the fall line of which leads through the idler sheave at the top of the boom, thence through a snatch block at the foot of the mast and thence to the lower drum of the hoisting engine, which is operated by the engineer.

Second. The boom is raised or lowered by a seven part tackle of ⅝ in. hoisting cable, the fall line of which leads through a snatch block at the foot of the mast and thence back to the upper drum on engine, which is operated by the engineer.

Third. The boom is swung laterally by one five part tackle (on each side) of 1½ in. manila rope, the fall line of which is led through a series of snatch blocks, which prevents the lines from fouling other parts of the traveler, to the outside winch head on the hoisting engine. Both of these lines are operated by one winch head man.

Fourth. Each of the 15-ton trolley hooks is supported by a nine-part tackle of 1½ in. manila rope, the fall line of which passes through a snatch block of two idlers at the forward end of cantilever arm and thence back through a number of deck sheaves, which keep the lines from fouling other parts, to the inside winch head of engine. As there are two trolleys, one fall line leads to each inside winch head on the engine. This fall line is also used for traversing the trolley, there being sufficient tension in the fall line, when holding the load, to move the trolley forward, the trolley being also under the control of the trolley tail line. One winch head man is required to operate each trolley tail line.

Fifth. The trolley tail line leads from its fastening to the trolley, through two snatch blocks to a cavel on the deck of the traveler. This arrangement is slightly different from that shown in Fig. 9. In order to keep the trolley under control when it is being hauled forward by means of its own fall line, the tail line which is snubbed around the cavel, as just mentioned, is paid out at the required speed from the cavel. When the trolley is being hauled towards the rear of the traveler for another load, the trolley fall line and the trolley tail line are interchanged from the position just described, the trolley tail line being wrapped around the winch head, as shown in Fig. 9, and used to haul the trolley back, the trolley fall line being snubbed around the cavel and paid out at the required speed. The entire attention of one man is required for each trolley tail line.

Sixth. In addition to the lines shown in Fig. 9, there are two runner lines (shown on Fig. 10 and marked No. 1 and No. 2), each of which passes from the load to a snatch block fastened to a stump and leads from the snatch block over the end of the traveler to the outside winch head of engine on which they are operated simultaneously with the swinging lines. These lines are operated by one of the regular men on the traveler.

Six men have been concentrated in handling lines on one side of the traveler, 12 men being required for both sides. Two of these men are usually available for handling signals, as they are not continuously employed with their lines. A third signal man, with the assistance mentioned above, transmits all signals. This gives a total of 13 men on top of the traveler. 37 additional men were required to fill the crew for this work.

Figure 10 shows all lines in operation, in the erection of the 195 ft. tower of Clear Creek viaduct. The two booms are placing two columns with boom tackles No. 1 and No. 2; trolleys No. 3 and No. 4 are simultaneously placing two other columns for the same tower; runner lines No. 1 and No. 2 are in service ready to outhaul these columns to their exact location; trolleys No. 1 and No. 2 are lowering to the ground two loads of sway bracing, which will afterwards be picked up and placed in position by the runner lines No. 1 and No. 2, at present running to the stump and being used for outhauling. This illustration also shows a carload of columns which have been run part way through the traveler, which will be lifted from the car by the trolleys and lowered to the ground.

As shown, the traveler is employed to its maximum capacity and working 50 men. The viaduct, which is 210 ft. from base of rail to ground, partly on a 10 degree curve, was erected in 28 working days by the forces of the bridge and building department under the direction of F. J. Herlihy.

On Feb. 1, 1909, the status of work on the New York State Barge Canal was as follows: Work under contract, 191.1 miles; additional plans completed, 10.2 miles; plans over 75 per cent completed, 71.0 miles; other plans in progress, 45 miles.

The U. S. Navy Department is again calling for bids for constructing the new dry dock for the Naval Station at Pearl Harbor, Hawaii. Bids for the work were opened Dec. 1 last, but were rejected owing to lack of sufficient funds to construct a dock 1,200 ft. long as contemplated. The plans have been revised shortening the dock to 620 ft.

Unclassified and General Articles

Note: This section is devoted to methods and cost articles on construction work not properly coming under any of the preceding classifications.

Methods and Cost of Tunneling on the Alaska Central Railway.*

The work considered comprises seven short tunnels, ranging from 193 ft. to 955 ft. long, located on the Alaska Central Ry., between miles 48¼ and 52. Dimensions, quantities, etc., for the several tunnels are shown by Table I. Tunnel No. 1 was located at mile 48¼, 1¼ miles from the end of completed track, and tunnels Nos. 2 to 7, inclusive, at mile 52, 5 miles by railway line and 3 miles by wagon road from the end of track.

TABLE I STATISTICS OF TUNNELS, ALASKA CENTRAL RY., SHOWING DIMENSIONS, QUANTITIES, ETC.

	Length		Quantities, cubic yards						
			Totals			Per Lin. Ft.			
No. Tunnel	Partial ft	Total ft	Standard Cross Section	Overbreak	Total Cross Section.	Standard Cross Section.	Overbreak.	Total Cross Section.	Per Cent. Overbreak in Tunnel Excavation.
1	....	699	10,186	2,800	12,986	14.572	4.006	18.578	27%
2	....	300	3,622	300	3,922	12.072	1.000	13.072	8.3%
3	776	....	.....	....	.....	.....	....	.....	....
3	179	955	10,241	600	10,841	10.723	.505	11.228	5.8%
4	127	....	.....	....	.....	.....	....	.....	....
4	287	414	4,539	200	4,739	10.964	.483	11.447	4.4%
5	....	304	3,444	282	3,726	11.329	.928	12.257	11.1%
6	....	193	2,630	200	2,380	13.626	1.037	14.663	7.1%
7	196	....	.....	....	.....	.....	....	.....	....
7	200	....	.....	....	.....	.....	....	.....	....
7	180	576	6,986	678	7,664	12.128	1.178	13.306	9.1%
						Average yardage per ft.			Average.
Totals ..	1,945	3 441	41,648	5,060	46,708	12.074	1.500	13.574	12.1%

Transportation was obtained for tunnel No. 1 by a wagon road from the end of the track to the bottom of the hill at the tunnel, and from there materials and supplies were hauled ¼ mile up the hill on sleds.

Transportation for supplies, tools, etc., for tunnels Nos. 2 to 7 inclusive were obtained by wagon road to compressor, three miles from the south end of tunnel, and carried on men's backs and by horses from there to the tunnel sites. The north end of tunnel No. 7 and its approach was furnished by a roundabout road across the Placer River glacier in the winter time.

Taken altogether the getting of supplies and tools from the compressor to the tunnels was very slow and expensive on account of the precipitous canyon sides. Men were let down on rope to start excavating in several places. A small 80-ft. suspension bridge was constructed for the purpose of transportation and to lay the 4-in. pipe line from compressors to the tunnels.

Rich and Harris had a contract for all grading and tunneling from 51⅞ to 53½. They began during the latter part of October and worked on the approach cuts and cuts adjoining tunnels Nos. 2, 3 and 7 during the time of their connection with the work, which accounts for the small amount of tunnel work done by them. As shown below they had shipped a small air compressor with capacity of 250 cu. ft. air per minute, Type C, Rand straight line compressor 12x12x16 ins. with one 40 H.P. boiler, pipe, drills, etc., complete, supposed to operate in one heading only at one time, with two 3-in. and one little giant Ingersol Sargent drills. The plant was not set up by them.

The work that was done on tunnel No. 2 on the north heading which was started on Dec. 14, 1905, by Rich and Harris was done by hand drilling. This tunnel was driven about 20 ft.; tunnel No. 3 south heading was driven about 50 ft.; or 70 ft. in all by hand work, when the company took the work over. The contractors had established camps which were used by the company later.

After the company took the work over from Rich and Harris, which was about the first of March, 1906, they continued to work on approach cuts and adjacent work and also on the south end of tunnel No. 3 by hand work. In the meantime they ordered additional plant to complete the work. It was decided that work should be done by working in two headings at one time with three 3¼ in. Ingersoll Sargent drills in each heading, making six 3¼-in. drills to provide air for. These require 610 cu. ft. per minute of air at 80 lbs. final pressure at the drills and 542 cu. ft. at 70 lbs. pressure, so that it was proposed to get a compressor with a capacity of 375 cu. ft. of free air per minute, making the total capacity of proposed plant 625 cu. ft. of air per minute. The maximum length of pipe line was to be 6,000 ft., about which there was considerable discussion as to the possibility of condensation in the pipes during the cold weather (which gets as low as 40 degrees below zero in the winter); also a possible reduction of air pressure, and also reduction in the amount of air reaching the drills. But no difficulty was noticed in actual practice later. Accordingly the writer was sent to Seattle to arrange with Mr. Browne, the Purchasing Agent, for the purchase of additional outfit required to

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*Compiled from a paper by G. A. Kyle, read before the Pacific Northwest Society of Engineers

TABLE II—SHOWING PROGRESS ON ALL TUNNELS AND OTHER INFORMATION REGARDING SAME.

Item—	Tunnel No. 1.	Tunnel No. 2.	Tunnel No. 3— South End.	Tunnel No. 3— North End.	Tunnel No. 4.	Tunnel No. 5.	Tunnel No. 6.	Tunnel No. 7.
Date work commenced	Jan. 16-06	Dec. 20-05	Dec. 14-05	Feb. 28-06	June 21-06	Dec. 24-05	June 18-06	May 24-06
Date work finished	Oct. 8-06	May 12-06	July 11-06	July 11-06	Nov. 30-06	May 16-06	Nov. 7-06	Nov. 4-06
Total days required to complete tunnel	265	143	210	133	162	143	142	164
Date steam plant was started	Jan. 20-06	....	....	....	....	....	....	....
Date steam plant was burned	Apr. 14-06	....	....	....	....	....	....	....
Total days steam plant worked	84	....	....	....	....	....	....	....
Date started air plant	Apr. 28-06	Dec. 20-05	Feb. 28-06	Feb. 28-06	....	....	June 18-06	May 24-06
Date completion with air plant	Sept. 25-06	May 12-06	July 11-06	July 11-06	....	....	Oct. 15-06	Oct. 15-06
Total days use of air plant	150	143	133	133	....	....	120	145
Greatest weekly progress	28	32.5	43	50	28	23.5	26	49
Smallest weekly progress	21	20.	23	26.5	16.5	18	20	28
Average weekly progress while actually at work	24 5	26.2	33	35.7	20.5	21.1	14.3	40.1
Greatest monthly progress while actually at work	117.2	120.4	162.5	185	96.5	94.3	93.5	176.
Smallest monthly progress while actually at work	92.8	109.	110.	130.5	92.	89.	35.	168.
Average monthly progress while actually at work	108	112.3	141.4	153.	88.	90.4	64.3	172.
Average daily progress figuring from time air was used	....	3.46	3.20	3.20	....	....	1.61	3.97
Average daily progress beginning to finish	2.64	2.09	2.52	3.20	2.57	2.13	1.36	3.51
How built	Company Steam and Air	Company Air	Company Air	Company Air	Contract By Hand	Contract By Hand	Company Air	Company Air
No. of headings worked at once	1	1	1	1	1	1	1	2
Length of tunnel	699	300	529	426	414	304	193	576
Bonus paid to all employes, 50c per foot for every foot in each heading in excess of number of feet shown under each tunnel per week of seven days	24.5	32.0	32.0	32.0	....	....	35.0	35.0

TABLE III.—SHOWING CONDENSED TOTAL COST OF TUNNELS 1, [illegible] AND [illegible] ALASKA CENTRAL RAILWAY

[illegible] No.	[illegible]	[illegible] yards	[illegible] yards [illegible] ft	[illegible]	[illegible] ft	[illegible] per [illegible] yard	Remarks
[illegible]	[illegible]	12 [illegible]	[illegible]	$ [illegible]	$128 46	$7 [illegible]	Company work drilling by air [illegible]
[illegible]	306	[illegible]	11 67				
[illegible]	975	10 841	11 2[illegible]				
6	[illegible]	[illegible]	11 66				
[illegible]	[illegible]	7 664	12 11				
Total 2, 3, 6, 7	[illegible]	[illegible]	12 47	[illegible]	[illegible]	6 7[illegible]	"
4	414	4 739	11 [illegible]	[illegible]	[illegible]	4 77	Contract work drilling by hand
[illegible]	[illegible]	3,7[illegible]6	12 [illegible]	[illegible]	[illegible] 62	4 78	"
Total	[illegible]	46 [illegible]	13 [illegible]	$509 [illegible]	$[illegible] 83	$6.62	Average all tunnels

TABLE IV.—SHOWING WAGE SCALE FOR ALL TUNNELS DONE BY COMPANY FORCES

Position	Per month	Per day
Superintendent	*$[illegible]	
Walking boss	*[illegible]	
Shift bosses		$[illegible]
Muck bosses		[illegible]
Machine drillers		[illegible]
Machine helpers		[illegible]
Carpenters		[illegible]
Blacksmiths		[illegible]
Powder thawer		[illegible]
Machinist	[illegible]	
Engineers	[illegible]	
Firemen		[illegible]
Muckers		[illegible]
Carmen		[illegible]
Other general labor		[illegible]

*And board. Paid their own board at $[illegible] per week.

[illegible] drills in tunnels Nos. 2, 3, 6 and 7, which was to consist of one compressor with capacity of 375 cu. ft. of air per minute at 100 lbs. pressure, three 40 H. P. boilers, one electric light plant to light tunnels and camp, and the necessary 4, 3 and 2½ in. air pipe, etc., complete.

Table V shows the plant and accessories used on these tunnels. In the meantime the company was working on the approach cuts to the different tunnels, which were extremely heavy and the outside work from mile 17 to 55, and drove the south end of tunnel No. 3, 25 ft. more by hand, making 75 ft. in all of this tunnel that was driven by hand and 95 ft. in all of tunnels Nos. 2, 3, 6 and 7 that were driven by hand, all the balance being driven by air. The air plant for the above tunnels was set up and a house built for same. The actual work of driving began Feb. 28, 1906, on the north end of tunnel No. 3 with air, and was prosecuted continuously until the work was finished.

Tunnel No. 1 was built by company forces and was begun Jan. 16, 1906. This tunnel was driven entirely from the north end on account of a snow slide on the south end, making it impossible to work on that end, as the work was mostly done in the winter months. The tunnel is 629 ft. long. The first 250 ft. was driven with steam power and drills. The character of material is of a hard rocky slate and is evidently in an ancient slide from the mountain, as the strata were badly broken up, which caused a great amount of overbreak outside of the standard section, the same being 27 per cent. This tunnel was on a 11° curve and was widened to give a minimum clearance of 18 ins. for the maximum length passenger car. The size of the tunnel was 17 ft. wide between timbers and 21 ft. from top of rail to clearance at top of timbers. Timber was used for 396 ft. in the north end. The balance was left unlined, but later had to be lined nearly its whole length at an extra high cost, which is not included in the costs as shown in tables.

The steam plant used in driving the first 250 ft. of the tunnel was 1 40 HP. boiler, 1 40 HP. boiler, 3 3¼ in. Rand drills were used in the heading. The work carried on with the following force in each shift of 10 hours (although work was carried on with day and night shifts during a short period):

- 1 Foreman.
- 3 Machine drillers.
- 3 Machine driller helpers.
- 1 Muck boss.
- 10 Muckers, 2 in head and 8 on bench.
- 1 Light tender.
- 1 Man on dump.
- 1 Man on cars.
- 1 Horse.
- 1 Engineer.
- 1 Fireman.
- 1 Blacksmith.

Making 24 men and 1 horse per shift.

The timbering was not kept up with the bench, as the material stood sufficiently well for the men to work, although it was considered dangerous at times.

There were used in blasting 21 or 22 holes in the heading 8 to 10 ft. deep, and the bench was taken out in two lifts generally. The heading was run from 40 to 60 ft. ahead of the bench and scaffolding used to dump the muck from heading directly into the cars from above, two plank runways supported on trestle being used for the purpose.

The steam plant was discontinued on April 11, 1906, as the heat from the escaping steam at the drills made the tunnel too hot for the men to work. The progress with the steam plant was satisfactory with the above exception and seemed to be about the limit that steam can be used economically, viz., 250 ft. from the end of tunnel. The steam was carried from the boilers to the drills in a 2½-in. pipe and the escaping steam was carried from the drills back out of the tunnels in a [illegible]-in. pipe enclosed in a wooden box with the 2½-in. steam pipe to decrease the heat. The progress during the 84 days that the steam plant was used was 250 ft., and the progress made while the air drills were working was about 26 ft. per day, so that about the same progress was made during

TABLE V.—SHOWING EQUIPMENT USED ON TUNNELS NOS. 2, 3, 6 AND 7

1 40 H. P. Economy boiler complete with stack and injector
3 40 H. P. return tubular boilers with stack and injector
2 4½"x3"x4" Gardner duplex feed water heater
1 100 H. P. Watson's feed water heater
1 14"x14"x22" Type C Rand compressor, capacity 375 ft. free air, [illegible] pressure.
1 12"x12"x16" Type C Rand compressor, capacity 250 ft. free air, [illegible] pressure.
1 30"x8' air receiver
1 30"x10" air receiver
2000 ft. 4" gas pipe.
3000 ft. 3" gas pipe.
3000 ft. 2½" gas pipe.
[illegible] ft. 2" gas pipe.
2 3¼" Rand drills.
2 3⅝" Rand drills.
9 3¼" Ingersoll drills.
9 columns complete with arms
6 tripods
2 Little Jap drills with columns complete
1300 ft. 1" air hose
[illegible]00 lbs. X drill steel
2 blacksmith outfits
Pipe tools
Drill repair parts
Pipe fittings
Extra receiving and discharge valves for each compressor.

TABLE VI.—SHOWING CONTRACT PRICES FOR TUNNELS NOS. [illegible] AND [illegible] AND FOR TIMBER WORK IN TUNNEL NO. 1

Tunnel No. 1	
Timber in place	$20.00 per M. ft.
Cordwood in place, ordinary section	3.00 per cord
Cordwood in place, large section	[illegible] per cord
Tunnel No. [illegible]	
Excavation per cu. yd. 14 ft. section	$[illegible]
Excavation per cu. yd. 14 ft. section	[illegible]
Excavation per cu. yd. 1[illegible] ft. section	[illegible]
Tunnel No. [illegible]	
Excavation per cu. yd. 14 ft. section	$[illegible]

The above included all labor, explosives, etc. Company furnished cars and track and [illegible].

TABLE VII.—SHOWING COST OF EXPLOSIVES DELIVERED AT END OF RAILWAY TRACKS FOR ALL TUNNELS DONE BY COMPANY FORCES

Dynamite, [illegible] per cent	$[illegible] per [illegible]
Dynamite, [illegible] per cent	[illegible] per [illegible]
Dynamite, 40 per cent	[illegible] per [illegible]
Black powder	[illegible] per [illegible]
Champion powder	[illegible] per [illegible]
Vigorit	[illegible] per [illegible]
Tonite	[illegible] per [illegible]
Caps	[illegible] per 100
Fuse	[illegible] per 100 ft.
Electric exploders, [illegible] to 14 [illegible] average [illegible] length [illegible] ft.	$[illegible] per 100 ft.

TABLE VIII.—SHOWING CONDENSED ITEMIZED COST OF TUNNEL NO. 1.

Item.	Total Cost.			Cost per Cu. Yd.			Cost per Lin. Ft.			Cost per lin. ft. of hole drilled.
	Mat.	Lab.	Total.	Mat.	Lab.	Total.	Mat.	Lab.	Total.	
Compressor and steam plant	2,453.76	302.10	2,755.86	0.189	0.023	0.212	3.510	0.433	3.943	0.134
Fuel compressor and steam plant	2,340.93	1,596.00	3,936.93	0.181	0.123	0.304	3.346	2.282	5.628	0.192
Engineers and firemen compressor plant	....	2,192.00	2,192.00	.....	0.169	0.169	.....	3.136	3.136	0.107
Total compressor plant	4,794.69	4,090.10	8,884.79	0.370	0.315	0.685	6.856	5.851	12.707	0.433
Pipe line connections, etc	1,482.85	160.00	1,642.85	0.114	0.012	0.126	2.121	0.229	2.350	0.079
Grand total compressor plant	6,277.54	4,250.10	10.527.64	0.484	0.327	0.811	8.977	6.080	15.057	0.512
Lighting tunnel	1,510.30	1,497.20	3,007.50	0.116	0.116	0.232	2.161	2.142	4.303	.....
Blacksmithing	454.00	3,998.68	4,452.68	0.035	0.309	0.344	0.649	5.720	6.369	.....
Labor on excavation	......	55,501.70	55,501.70	.....	4.288	4.288	.....	79.401	79.401	.....
Explosives	8,629.00	......	8,629.00	0.668	.....	0.668	12.345	.....	12.345	.....
Material used in exc'vat'n for scaffolding, etc	1,652.30	179.20	1,831.50	0.128	0.014	0.142	2.364	0.256	2.620	.....
Roads and trails	......	1,200.00	1,200.00	.....	0.093	0.093	.....	1.717	1.717	.....
Timber lining	3,480.95	4,351.69	7,832.64	0.269	0.336	0.605	4.979	6.226	11.205	.....
Engineering and superintendence	......	3,800.00	3.800.00	.....	0.294	0.294	.....	5.436	5.436	.....
Total cost of tunnel	22,004.09	74,778.57	96,782.66	1.700	5.777	7.477	31.475	106.978	138.453	.....

TABLE IX.—ITEMIZED COST OF TUNNEL NO. 1. COST OF COMPRESSOR PLANT.

Items.	Cost.			Per Lin. Ft.			Per Cu. Yd.			Cost per lin. ft of hole drilled.
	Mat.	Lab.	Total.	Mat.	Lab.	Total.	Mat.	Lab.	Total.	
Lighting compressor house, 125 gals. oil at 40c	50.00	......	50.00	0.072	.....	0.072	0.004	....	0.004	0.003
Dep of boilers comp. plant drills, etc., 30% of original cost at end of track	2,127.76	......	2,127.76	3.044	.....	3.044	0.164	.....	0.164	0.104
Lubricating oil for compressor	60.00	......	60.00	0.086	.....	0.086	0.005	.....	0.005	0.003
Freighting machinery for plant, 25 tons at 50c per ton mile	......	50.00	50.00	.....	0.072	0.072	.....	0.004	0.004	0.002
Lubricating oils for drills	32.00	......	32.00	0.046	.....	0.046	0.002	.....	0.002	0.001
Machinist repairing plant	......	106.50	106.50	.....	0.153	0.153	.....	0.008	0.008	0.005
Building for compressor plant	184.00	145.60	329.60	0.262	0.208	0.470	0.014	0.011	0.025	0.016
Total	2,453.76	202.10	2,755.86	3.510	0.433	3.943	0.189	0.023	0.212	0.134
266 tons coal at end of track, at $8.80 per ton	2,340.93	......	2,340.93	3.346	.....	3.346	0.181	.....	0.181	0.114
Freighting 266 tons coal from end of track, at 50c per ton mile	......	532.00	532.00	.....	0.761	0.761	.....	0.041	0.041	0.026
Miscellaneous labor hauling coal and ashes 8 mos. at $85.00	......	680.00	680.00	.....	0.972	0.972	.....	0.052	0.052	0.033
Horses, hauling coal and ashes 8 mos., at $48.00	......	384.00	384.00	.....	0.549	0.549	.....	0.030	0.030	0.019
Total haul	2,340.93	1,596.00	3,936.93	3.346	2.282	5.628	0.181	0.123	0.304	0.192
5 mos. engrs., at $250 per mo. (2 men)	......	1,250.00	1,250.00	.....	1.788	1.788	.....	0.096	0.096	0.060
150 days firemen, at $3.00	......	450.00	450.00	.....	0.644	0.644	.....	0.035	0.035	0.022
82 days firemen, at $6.00 (2 men)	......	492.00	492.00	.....	0.704	0.704	.....	0.038	0.038	0.025
Total engineers and firemen	......	2,192.00	2,192.00	.....	3.136	3.136	.....	0.169	0.169	0.107
Dep. of pipe line and fittings, 60% of 1st cost	250.77	......	250.77	0.359	.....	0.359	0.019	.....	0.019	0.012
Hose and parts, 1st cost	1,232.08	......	1,232.08	1.762	.....	1.762	0.095	.....	0.095	0.060
Laying pipe line, 800 ft. at 20c	......	160.00	160.00	.....	0.229	0.229	.....	0.012	0.012	0.007
Total pipe line	1,482.85	160.00	1,642.85	2.121	0.229	2.350	0.114	0.012	0.126	0.079
Grand total compressor plant and pipe	6,277.54	4,250.10	10.527.64	8.977	6.080	15.057	0.484	0.327	0.811	0.512
Lighting Tunnel—										
Candles	493.00	......	493.00	0.705	.....	0.705	0.705	.....	0.038	.....
Coal oil	729.00	......	729.00	1.043	.....	1.043	0.056	.....	0.056	.....
Gasoline	209.00	......	209.00	0.300	.....	0.300	0.016	.....	0.016	.....
Buckeye lights and torches, dep., 50%	79.30	......	79.30	0.113	.....	0.113	0.006	.....	0.006	.....
Freight hauling 17 tons 4 miles, at 40c per ton mile	......	27.20	27.20	.....	0.039	0.039	.....	0.002	0.002	.....
Labor, 245 days, attended lights, $6	......	1,470.00	1,470.00	.....	2.103	2.103	.....	0.114	0.114	.....
Total cost of lighting tunnel	1,510.30	1,497.20	3,007.50	2.161	2.142	4.303	0.116	0.116	0.232	.....
Blacksmithing—										
265 days, at $9.00 (2 men)	......	3,975.00	3,975.00	.....	5.686	5.686	.....	0.307	0.307	.....
14.8 tons coal, at $20 per ton, at end of track	296.00	......	296.00	0.423	.....	0.423	0.023	.....	0.023	.....
14.8 hauled from end track to tunnel, at 40c per ton mile, = $1.60 per ton	......	23.68	23.68	.....	0.034	0.034	.....	0.002	0.002	.....
Depreciation of tools, 50% of 1st cost	158.00	......	158.00	0.226	.....	0.226	0.012	.....	0.012	.....
Total blacksmithing	454.00	3,998.68	4,452.68	0.649	5.720	6.369	0.035	0.309	0.344	.....
Engineering	......	2,000.00	2,000.00	.....	2.861	2.861	.....	0.155	0.155	.....
Superintendence	......	1,800.00	1,800.00	.....	2.575	2.575	.....	0.139	0.139	.....
Total engineering and superintendence	......	3,800.00	3,800.00	.....	5.436	5.436	.....	0.294	0.294	.....
Bonus	......	1,475.60	1,475.60	.....	2.111	2.111	.....	0.114	0.114	.....
Labor, including shift bosses	......	53,282.10	53,282.10	.....	76.226	76.226	.....	4.116	4.116	.....
Horses, 496 days at $1.50	......	744.00	744.00	.....	1.064	1.064	.....	0.058	0.058	.....
Total labor in tunnel excavation	......	55.501.70	55.501.70	.....	79.401	79.401	.....	4.288	4.288	.....
Explosives, powder	7,880.00	......	7,880.00	11.273	.....	11.273	0.609	.....	0.609	....
Fuses, caps, exploders, lead wires	749.00	......	749.00	1.072	.....	1.072	0.059	.....	0.059	.....
Total explosives	8,629.00	......	8,629.00	12.345	.....	12.345	0.668	.....	0.668	.....
Tools, hand	135.20	......	135.20	0.193	.....	0.193	0.011	.....	0.011	.....
Tools, drill steel, dep. 50% 1st cost	221.50	......	221.50	0.317	.....	0.317	0.017	.....	0.017	.....
Cars, tracks, dep	389.00	......	389.00	0.556	.....	0.556	0.030	.....	0.030	.....
Miscellaneous hardware and sundries	428.60	......	428.60	0.614	.....	0.614	0.033	.....	0.033	.....
Lumber for scaffolding and miscl., 39,383 ft. B. M., at $12.00	478.00	......	478.00	0.684	.....	0.684	0.037	.....	0.037	.....
Hauling above material, 112 tons, at $1.60	......	179.20	179.20	.....	0.256	0.256	.....	0.014	0.014	.....
Total material	1,652.30	179.20	1,831.50	2.364	0.256	2.620	0.128	0.014	0.142	.....
Total making roads and trails	......	1,200.00	1,200.00	.....	1.717	1.717	.....	0.093	0.093	.....
Total excavation	10,281.30	56,880.96	67,162.26	14.709	81.374	96.083	.....	.....	.....	.....
Total timber lining (see H-2)	3,480.95	4,351.69	7,832.64	4.979	6.226	11.205	0.269	0.336	0.605	.....
Total cost of tunnel	22,004.09	74.778.57	96.782.66	31.475	106.978	138.453	1.700	5.777	7.477	.....

Tunnel, 699 ft. long. Excavation, 12,986 cu. yds. Timber, 396 ft.

TABLE X.—SHOWING ITEMIZED COST OF TIMBERING 306 FT. OF TUNNEL NO. 1.

Item	Cost Mat.	Cost Labor	Cost Total	Per Lin. Ft. Mat.	Per Lin. Ft. Labor	Per Lin. Ft. Total	Per Cu. Yd. Mat.	Per Cu. Yd. Labor	Per Cu. Yd. Total
[illegible] 58 ft. timbering—									
[illegible] cords wood at [illegible] per cord		[illegible]	[illegible]						
[illegible] cords wood at [illegible] per cord	[illegible]		[illegible]						
Total cord wood	[illegible]	[illegible]	[illegible]				[illegible]		
[illegible] ft. B. M. timber at [illegible]		[illegible]	[illegible]						
[illegible] at [illegible]	[illegible]		[illegible]						
[illegible] ft. B. M. timber at [illegible]	[illegible]		[illegible]						
Total for timber	[illegible]	[illegible]	[illegible]					[illegible]	
Total for 58 ft. lin. lining	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			
[illegible] for 248 lin. ft.—									
[illegible] at [illegible]	4.[illegible]		[illegible]	[illegible]		[illegible]			
[illegible] or hotel	667.50		[illegible]	[illegible]		[illegible]			
[illegible] ft. B. M. timber at [illegible] at end of track	1,278.[illegible]		[illegible]	[illegible]		[illegible]			
[illegible] ft. B. M. timber at [illegible]		[illegible]	[illegible]		[illegible]	[illegible]			
Timber framed by hand		[illegible]	[illegible]		[illegible]	[illegible]			
Total timber for 248 ft. tunnel	1,998.7[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	
[illegible] cords wood at [illegible] labor		[illegible]	[illegible]						
[illegible] cords wood at [illegible] labor		271.[illegible]	[illegible]						
[illegible] cords wood at [illegible] material and track	[illegible]		[illegible]						
Total cords wood back filling	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		
Cost of 248 lin. ft. lining	2,761.62	[illegible]	[illegible]	10.241	[illegible]	21.[illegible]			
Total for 306 lin. ft. tunnel lining	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Total for [illegible] lin. ft. tunnel lining	3,48[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	11.2[illegible]	[illegible]	[illegible]	[illegible]

Total length of tunnel, [illegible] ft. Cu. yds. in tunnel, 12,986. Total length timbered, 306 ft.

the steam plant's operation as with the air plant, which was 26.2 ft. This might be accounted for by the fact that from the time that the steam plant was discontinued, April 14, 1906, until April 25, 1906 (11 days), when the air plant was started, there was not much work done in the tunnel excepting to work on the bench, which was considerably behind at that time. From the time the air plant was installed until Sept. 25, 1906, 150 days, the tunnel was worked continuously and was practically finished. The time from Sept. 25 to Oct. 8, the time that the tunnel is shown as completed in Table II, was employed in dressing up and completing the timbering of tunnel. The actual days worked on the tunnel were 231, making the actual progress while work was going on 3 ft. per day. Considerable trouble was had in keeping the force up to the standard number in this tunnel on account of the dangerous character of the rock. Table IX shows in detail the cost of this tunnel in general, which includes timbering.

Total cost of tunnel No. 1 per lineal foot was	$138.46
Including cost of timbering 306 ft. which cost	11.21
Leaving actual cost of excavation per lineal foot	$127.25
Total cost per cu. yd.	7.46
Including cost of timbering 306 ft., which cost	.29
Leaving actual cost per cu. yd. for excavation	$7.17
The average amount of dynamite that was used per lineal foot equals	63.3 lbs.
Per cubic yard excavation in tunnel equals	3.57 lbs.
Per lineal foot of hole drilled in tunnel equals	2.23 lbs.

Referring to the statement of air and steam plant:

The cost per lineal foot of tunnel is	$15.06
Per cubic yard in tunnel is	.81
Per lineal foot of hole drilled is	.51

To get the actual cost of drilling there must be added the wages of the drillers and helpers, which will make the amount to add to the above item as follows:

Per lineal foot	$7.03
Per cubic yard	.38
Per lineal foot of hole drilled	.23

Making the total cost of drilling as follows:

	For Steam and Air Plant	Cost of Labor and Repairs	Total
Cost per lineal foot	$15.06 plus	$7.03 equals	$[illegible]
Cost per cubic yard	.81 plus	.38 equals	1.1[illegible]
Cost per lineal foot of hole drilled	.51 plus	.23 equals	.74

Returning to the tunnels on page 52, as stated before, the actual work of driving tunnel No. 2 by air was begun Feb. 20, 1906, and finished May 12, 1906, requiring 81 days to complete the remaining 280 ft., or an average of 3.46 ft. per day.

Tunnel No. 3 was driven from both ends, from the south end 529 ft. and from the north end 126 ft. by air drills. 75 ft. of the south end was driven by hand, and the remaining 454 ft. by air drills. Work on the south end began with the air drills on Feb. 20, 1906, and finished July 11, 1906. The north end was begun [illegible] 28 and finished July 11, 1906, an average of 3.29 lin. ft. per day on the south end and the same on the north end.

Tunnel No. 6 was begun with air June 18, 1906, and finished Oct. 15, 1906, requiring 120 days to finish, an average per day of 1.61 lin. ft. The slow progress of this tunnel is evidently on account of the lack of power to run three headings at a time, as they were working in tunnel No. 7 at both ends at the same time, and it was impossible to carry all the headings on full force at once.

TABLE XI.—SHOWING EQUIPMENT USED FOR TUNNEL NO. 1.

1 40 H. P. [illegible] water tube boiler with [illegible] injector and feed pump
1 12x12x14 inch Franklin straight line air compressor, steam driven, capacity [illegible] cu. ft. of air per minute
1 40 inch by 10 ft. air receiver
7[illegible] ft. 4-inch gas pipe
4[illegible] ft. 2½-inch gas pipe
[illegible] ft. 1-inch gas pipe
400 ft. 1-inch armored rubber air hose
1[illegible] ft. 2-inch armored rubber air hose
2 3¼ Rand drills
1 3⅛ Rand drill
2 2¾ Rand drills
[illegible] Tripods
3 Columns
2 Arms
1,000 lbs. X Steel
Blacksmith outfit
Pipe tools
Pipe fittings
Repair parts for drills

TABLE XII.—SHOWING COMPRESSOR STATISTICS OF TUNNEL NO. 1.

Items	Total	Per day	Per lin. ft. tunnel	Per cu. yd.	Per lin. ft. of hole drilled
Compressor, boiler, etc., depreciation, etc.	$[illegible]		$[illegible]	$[illegible]	$[illegible]
Fuel	[illegible]		[illegible]	[illegible]	.15
Engineers, firemen and [illegible]	[illegible]		[illegible]	[illegible]	.11
[illegible]	[illegible]		[illegible]	[illegible]	[illegible]
Total	$[illegible]		$15.06	.81	.51
Total [illegible] ft. of hole drilled					[illegible]
Feet of hole per cu. yd.					[illegible]
Cu. yd. per lin. ft. of [illegible]					[illegible]
Lin. ft. of hole per ft. of tunnel					[illegible]
Cu. yds. per ft. of tunnel					[illegible]
Length ft. of tunnel					[illegible]
Cu. yds. in tunnel					12,986

Note.—The compressor items include all costs of drilling except labor of operating drills, which is included in cost of excavation.

TABLE XIII.—SHOWING CONDENSED ITEMIZED COST OF TUNNELS 2, 3, 6 AND 7.

Items.	—Total Cost.—			—Cost per Lin. Ft.—			Cost per Cu. Yd.			Cost lin.ft. hole.
	Mat.	Lab.	Total.	Mat.	Lab.	Total.	Mat.	Lab.	Total.	
Compressor Plant—										
Machinery dep., lightin.., frt. on same, etc	$5,204.81	$525.80	$5,730.61	2.571	.260	2.831	.206	.020	.226	.092
Fuel for compressor	8,904.00	4,026.00	12,930.00	4.399	1.989	6.388	.352	.159	.511	.210
Engineer and fireman	......	3,470.00	3,470.00	.....	1.714	1.714	....	.137	.137	.056
Total compressor plant	14,108.81	8,021.80	22,130.61	6.970	3.963	10.933	.558	.316	.874	.358
Pipe line	1,755.94	1,450.24	3,206.18	.868	.716	1.584	.069	.058	.127	.052
Grand total compressor and pipe line	15,864.75	9,472.04	25,336.79	7.838	4.679	12.517	.627	.374	1.001	.410
Excavating—										
Tools	1,453.57	......	1,453.57	0.718	.....	0.718	.057	.....	.057	.....
Labor	......	107,800.75	107,800.75	.....	53.261	53.261	.....	4.261	4.261	.....
Roads and trails	......	1,600.00	1,600.00	.....	.791	.791	.....	0.063	.063	.....
Explosives, cap and fuse	16,829.61	......	16,829.61	8.315	.....	8.315	.665	.....	.665	.....
Lumber, etc.	1,772.07	540.00	2,312.07	.875	.267	1.142	.070	.021	.091	.....
Engineering and superintendence	......	6,135.70	6,135.70	.....	3.031	3.031	.....	.242	.242	.....
*Total excavation	20,055.25	116,076.45	136,131.70	9.909	57.350	67.259	.792	4.587	5.379	.....
Total lighting tunnel	2,947.92	1,552.50	4,500.42	1.457	0.767	2.224	.116	.061	.177	.....
Total blacksmithing	607.21	5,316.55	5,923.76	0.300	2.627	2.927	.024	.210	.234	.....
Total cost tunnels 2, 3, 6, 7	39,475.13	132,417.54	171,892.67	19.504	65.423	84.927	1.559	5.232	6.791	.....

*Note:—Cost of excavation includes cost of operating drills, labor and repairing of drills, etc.

Compressor machinery—										
(1) Dep. compressor plant, interest, etc., 30% 1st cost	4,860.91	......	4,860.91	2.402	.....	2.402	.192	.....	.192	.088
Lubicating oil for compressor	63.90	......	63.90	0.032	.....	0.032	.003	.....	.003	.001
Compressor building	230.00	190.00	420.00	0.113	0.094	0.207	.009	.007	.016	.007
Machinist labor repairing plant	......	185.80	185.80	.....	0.092	0.092	.....	.007	.007	.003
Freighting machinery, 60 tons, at $2.50 per ton	......	150.00	150.00	.....	0.074	0.074	.....	.006	.006	.002
Lighting compressor building, 125 gals. coal oil, at 40c	50.00	......	50.00	0.024	.....	0.024	.002	.....	.002	.001
Total compressor machinery	5,204.81	525.80	5,730.61	2.571	0.260	2.831	.206	.020	.226	.092
(4) Pipe and fittings, 60% 1st cost, for dep. and interest	1,138.99	......	1,138.99	0.563	.....	0.563	.045	.....	.045	.019
Hose and parts	497.10	......	497.10	0.246	.....	0.246	.020	.....	.020	.008
Lubricating oil for drills	119.85	......	119.85	0.059	.....	0.059	.005	.....	.005	.002
Laying pipe line from compressor to tunnels	......	1,362.74	1,362.74	.....	0.673	0.673	.....	.054	.054	.022
Hauling 35 tons pipe, at $2.50 per ton	......	87.50	87.50	.....	0.043	0.043	.....	.003	.003	.001
Total pipe line	1,755.94	1,450.24	3,206.18	0.868	0.716	1.584	.070	.057	.127	.052
(2) 980 tons coal at end of track, at $8 80 per ton	8,624.00	......	8,624.00	4.261	.....	4.261	.341	.....	.341	.140
980 tons hauling, at $2.50	......	2,450.00	2,450.00	.....	1.211	1.211	.....	.097	.097	.040
Miscellaneous labor hauling coal and ashes, 8 mos., at $125	......	1,000.00	1,000.00	.....	0.494	0.494	.....	.039	.039	.016
Fire wood	280.00	......	280.00	0.138	.....	0.138	.011	.....	.011	.005
Horses hauling coal and ashes, at compressor, 8 mos., at $72.00	......	576.00	576.00	.....	0.284	0.284	.....	.023	.023	.009
Total fuel for compressor	8,904.00	4,026.00	12,930.00	4.399	1.989	6.388	.352	.159	.511	.210
(3) Engineers, 8 mos., at $250 per month	......	2,000.00	2,000.00	.....	0.988	0.988	.....	.079	.079	.032
2 firemen, 245 days, at $6.00 per day	......	1,470.00	1,470.00	.....	0.726	0.726	.....	.058	.058	.024
Total engineers and firemen	......	3,470.00	3,470.00	.....	1.714	1.714	.....	.137	.137	.056
Excavating—										
Bonus	......	3,749.50	3,749.50	.....	1.853	1.853	....	.1482	.1482	.....
Labor, including shift bosses and muck bosses	......	102,911.25	102,911.25	.....	50.845	50.845	.....	4.0676	4.0676	.....
Horses on cars, etc	......	1,140.00	1,140.00	.....	0.563	0.563	.....	.0451	.0451	.....
Total labor on tunnels	......	107,800.75	107,800.75	.....	53.261	53.261	.....	4.2609	4.2609	.....
Total roads and trails	......	1,600.00	1,600.00	.....	0.791	0.791	.....	.0633	.0633	.....
Explosives powder	15,367.37	......	15,367.37	7.593	.....	7.593	.608	.....	.608	.....
Fuse, caps, exploders, lead wire, etc	1,462.24	......	1,462.24	0.722	.....	0.722	.057	.....	.057	.....
Total explosives	16,829.61	......	16,829.61	8.315	.....	8.315	.665	.....	.665	.....
Hand tools	263.50	......	263.50	0.130	.....	0.130	.010	.....	.010	.....
Drill steel 50% original cost for dep	432.85	......	432.85	0.214	.....	0.214	.017	.....	.017	.....
Cars, tracks, etc., depreciation	757.22	......	757.22	0.374	.....	0.374	.030	.....	.030	.....
Total tools	1,453.57	......	1,453.57	0.718	.....	0.718	.057	.....	.057	.....
Miscellaneous hardware and sundries	838.03	......	838.03	0.414	.....	0.414	.033	.....	.033	.....
Lumber for scaffolding, 77,837 ft. B. M., at $12.00	934.04	......	934.04	0.461	.....	0.461	.037	.....	.037	.....
Hauling 216 tons lumber at $2.50 per ton	......	540.00	540.00	.....	0.267	0.267	.....	.021	.021	.....
Total lumber and hardware	1,772.07	540.00	2,312.07	0.875	0.267	1.142	.070	.021	.091	.....
Superintendence	......	2,535.70	2,535.70	.....	1.253	1.253	.....	.100	.100	.....
Engineering	......	3,600.00	3,600.00	.....	1.778	1.778	.....	.142	.142	.....
Total Engineering and Superintendence	......	6,135.70	6,135.70	.....	3.031	3.031	.....	.242	.242	.....
Total cost of excavating	20,055.25	116 076.45	136,131.70	9.909	57.350	67.259	.792	4.587	5.379	.....
Candles	960.12	......	960.12	0.474	.....	0.474	.038	.....	.038	.....
Coal oil	1,424.35	......	1,424.35	0.704	.....	0.704	.056	.....	.056	.....
Gasoline	408.45	......	408.45	0.202	.....	0.202	.016	.....	.016	.....
Buckeye lights and torches 50% original cost dep. and interest	155.00	......	155.00	0.077	.....	0.077	.006	.....	.006	.....
Hauling 33 tons at $2.50 per ton (5 mi.)	......	82.50	82.50	.....	0.041	0.041	.....	.003	.003	.....
Labor attending lights, 245 days at $6	......	1,470.00	1,470.00	.....	0.726	0.726	.....	.058	.058	.....
Total lighting tunnel	2,947.92	1,552.50	4,500.42	1.457	0.767	2.224	.116	.061	.177	.....
Blacksmithing—										
284 days blacksmithing at $4.50	......	1,278.00	1,278.00	.....	0.631	0.631	.....	.050	.050	.....
500 days blacksmithing at $4 00	......	2,000.00	2,000.00	.....	0.988	0.988	.....	.079	.079	.....
663 days blacksmithing at $3 00	......	1,989.00	1,989.00	.....	0.983	0.983	.....	079	.079	.....
19.82 tons blacksmith coal at $20.00 end track	396.54	......	396.54	0.196	.....	0.196	.016	.....	.016	.....
19.82 tons freighting same, $2 50 per ton	......	49.55	49.55	.....	0.025	0.025	.....	.002	.002	.....
Blacksmith tools, dep. 50% cost	210.67	......	210.67	0.104	.....	0.104	.008	.....	.008	.....
Total blacksmithing	607.21	5,316.55	5,923.76	0.300	2.627	2.927	.024	.210	.234	.....
Total cost tunnels 2-3-6-7	39,475.13	132,417.54	171 892.67	19.504	65.423	84.927	1.559	5.232	6.791	.....

Total length of tunnels 2-3-6 and 7, 2,024 ft. Total cu. yds. excavation 2-3-6 and 7, 25,850. Total lin. ft. holes drilled 2-3-6 and 7, 61,257.

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The Engineers Who Reported on the Panama Canal Are Each Rated at 24 H. C. P.

We now have the latest spring quotations on engineer's reports. Fifteen thousand dollars are to be paid to the six engineers who accompanied President Taft to Panama to settle finally the question as to the type of canal, for the type (sea level or lock) was contingent upon the safety of the proposed Gatun dam.

These engineers were selected upon the assumption—we assume—that no higher authorities could be found in the civil engineering profession. They are now to be paid $2,500 each for an expert opinion on a project involving the expenditure of some $300,000,000. Their fees amount to about $100 for each day's service. This is munificent.

The fee of $15,000 is just one two-hundredth part of 1 per cent of the total sum at stake, so that each engineer receives one twelve-hundredth part of 1 per cent for passing judgment on the greatest public works project of all times.

In the same daily papers that report the award of these engineering fees, we have an account of a law suit in which it is said that the leading counsel receives $1,000 a day for his services.

Where matters of great importance are at stake it is customary, the world over, to pay for professional services in some proportion to the amount of money involved—except in civil engineering. Here in this Panama case we have a daily payment to each of the consulting engineers equivalent to the combined wages of two dozen hod carriers, and then only because the work is of stupendous importance.

Col. Goethal's daily income makes him of about 12 hod carrier power. The State Engineer of New York is 1 hod carrier power, but then he has only a $100,000,000 piece of work to manage. Still let us take heart. Some day there may be a six billion dollar public works project, and then the engineer at the head of it will be a 250 hod carrier power man, and class with some of the larger lawyers.

Guarding the Unwary.

We commented last week on the absurd contention so often made that cost data should be guarded jealously for fear that some unwary one, not realizing that they are "edged and barbed with trouble," should mishandle them and come to grief. Perhaps some of our readers felt that we spoke more strongly than the occasion demanded. If so, we ask them to read the following editorial utterance of an esteemed contemporary.

> The selection of cost figures for presentation to the contractor is a matter which requires careful consideration and the exercise of discretion. Local conditions vary to such a large degree as to physical peculiarities, prices of labor and supplies, that the figures obtained on one job cannot be taken as a criterion of what they [illegible] somewhere else on a similar job. This is especially true of small jobs where the observations cover a small number of cases for a short period of time. [illegible] figures should represent the averages of a large number of observations, as they [illegible] to be misleading [illegible] to the [illegible] contractor or may be used by some unwary one in such a manner as to bring him to grief.
>
> This point was brought out quite forcibly in two papers presented at a meeting of the Boston Society of Civil Engineers at which the writer was present. One of these papers has been published recently in another contracting journal, but "The Contractor" held the position that the figures contained therein might be misleading. The paper took up the matter of making and driving concrete piles going into very minute details of the operation and finally deriving cost figures which involved these observations. The bulk of the data was obtained from only 20 piles, and in these 20 cases there were many variations in working conditions as the men became more dextrous, so that single cases varied widely from the final averages. The paper is a very able one and the figures are interesting as a study of those 20 piles, but they cannot be taken to represent the cost of concrete pile driving generally. The writer of the paper commented on this and discounted many of the figures.
>
> The paper immediately following the above described the manufacture and driving of about 12,000 concrete piles on two jobs. Here twice the speed of the first case was attained in driving in material equally hard, and other applications of the first observations to this case were similarly out of proportion. Unfortunately no detailed cost figures were presented on these 12,000 piles for a comparison.
>
> The contrast between the pieces of work in view of applying the observations of one to the other was very apparent to a person listening to the two papers.

It is a regret to us that we were not privileged to listen to the reading of these two papers. We were able only to do the next best thing—read them ourselves. Apparently we thus missed some of the "contrasts" so very apparent to the writer whose remarks we quote above. We did note, however, the contrast between having detailed driving and cost records of a 20-pile job and of not having any such records from a 12,000-pile job. It was unfortunate, as the writer whose remarks we quote says, that no detail cost figures were presented for the 12,000-pile job, but be it noted, none were presented. Now detailed cost figures for 20 piles are more cost data than no detailed cost figures for 12,000 piles, and so we published the records of the 20-pile job in ENGINEERING-CONTRACTING. So much in justification of our reprint of Messrs. Thompson and Fox's paper on the score of its contained cost data.

As a matter of fact, it was not the cost figures presented in this paper that gave it its principal value; it was the complete time records of the driving operations. They are the only such records that have ever been published. From them the authors of the paper draw a number of conclusions, all of which are worth knowing and most of which are applicable to any

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job of concrete pile work irrespective of local conditions. The careful reader, too, will get from the body of the paper other hints not contained in the conclusions and of which he can make use. So if we eliminate the knowledge of costs given by the paper, for fear that some fledgling contractor may be jarred from the secure nest of cost ignorance, we shall still find much of value to be got from the labors of the two engineers who worked out the record of this little job of construction with concrete piles. But why in the name of heaven should anyone think it necessary or advisable to eliminate the costs that were given and every detail of which was explained in the paper?

Is there any inherent quality in cost data that makes it necessary to keep them under cover whereas all other engineering data may be cast abroad on the four winds of heaven? We showed last week that such an idea was nothing short of absurd. But there is another thought which we did not then mention. Why assume that the very men who are selecting, analyzing and co-ordinating the most complex engineering data of other kinds and doing it safely are too stupid to handle cost data likewise? Is it because the critics of cost data tacitly assume that these data are of interest chiefly to contractors and that contractors are inferior in acumen and judgment to engineers? If there ever was a time when such an opinion was justified it is rapidly passing, if it has not already gone by. To assume that the contractor, the very foundation of whose success rests on his ability to judge of costs, cannot be trusted not to be misled by a few columns of cost figures not worked out by himself is too absurd to be impertinent.

An interesting experiment for producing ice in an easy and inexpensive way was made last winter in the vicinity of Balingen, in the Kingdom of Wurttemberg, Germany. The process is described in a recent consular report as follows:

A large wooden framework of two stories, each 10 ft. high, is put up. Each story has a cover of 18 parallel beams. Through the center a pipe incased to prevent freezing runs up to the upper cover. This pipe is connected with the water supply. At the top the water escapes over a rotating disk so that it is distributed evenly in the form of drizzling rain over the beams of the cover of both stories. The water drops continually from the beams and is changed into icicles by the cold winter temperature. These icicles grow until they reach from the top beams to the beams below, and finally to the ground floor. At a sufficiently low temperature 700 cu. ft. of ice can be produced in a single night from such a framework. The icicle assumes and keep the form of thick, separate columns, which can be broken without difficulty.

Concrete and Reinforced Concrete Section

Note:—This section is devoted to methods and cost of constructing concrete and reinforced concrete structures. It will cover the selection, testing and proportioning of concrete materials; laboratory tests of concrete; concrete mixing, transportation and placing; fabrication and placing of reinforcement, and form construction and erection. It will also contain articles on new and interesting developments in the design of reinforced concrete.

Concrete Fence Posts.

From observation of concrete fence posts your committee considers that the concrete post will heave very little or not at all, as posts set from two to five years ago are at present in all most perfect alinement, and not a loose or broken post was found. They appear sufficiently strong for all practical purposes after being properly cured and set. The claim that concrete posts reinforced with steel form lightning protectors appears reasonable. They will, of course, resist the action of fire and decay. They will not float and cannot be displaced so easily as wood posts. On the other hand, concrete posts must be carefully handled in loading and unloading and well cured before using. Fence wire in contact with their surfaces should be well galvanized. The concrete post is much heavier than the wood post and the cost of distributing and setting is about 25 per cent greater.

It would seem that the concrete post is particularly adapted to railroad use. Most of the post machines are cheap and portable and the materials used are in daily use on all roads using concrete; the materials are cheap and easily obtained.

Your committee corresponded with over 20 manufacturers of posts and postmaking machinery in the United States and Canada. A majority of these firms use or advise the use of Portland cement and gravel varying from the size of sand to pebbles which will pass a wire screen having meshes of from ½ to 1 in. sq. The ratio of cement and gravel is as 1 to 4. The methods of reinforcing and tamping concrete posts vary almost as much as those of fastening the fence wire to the posts. The machines are of various capacities and design—from the one-post hand mold to the "post per minute" power machine with continuous mixer attachment. The average total cubic content of the 7-ft. post is 0.825 cu. ft.; of the 8-ft. post, 0.95 cu. ft. The weights vary from 65 lbs. to 95 lbs., according to methods of manufacture and reinforcement used. Concrete posts retail for from 25 to 35 cts. per post. End and gate posts are of about three times the volume and cost of intermediate posts. In section, concrete posts vary from square or rectangular to triangular, half-round and circular. Reinforcements are of wire, wood, strap steel, steel and wire truss, wood and wire truss, chain scrap strips and expanded metal. Fence wire fastenings are also of various forms—from the wire loop around the post to the patent staple encasement. All the posts observed taper from a smaller top to a larger base. Some have very wide concrete block bases.

In response to invitations sent to all manufacturers four concrete post machine firms demonstrated their machines at Bay City, Mich., making 12 reinforced concrete posts each, which were tested at the Michigan Agricultural College.

These posts were tested for tensile strength; panels were erected to test the holding power of the fence in place as well as give the set posts impact tests and, if possible, to compare their strength of resistance to impact with wooden posts. They were tested in a machine of large capacity, 42-in. span, both ends supported, load applied in center. The following results were obtained at an average of 7 to 12 posts of each sort so tested:

Name of Mfr.	First crack	Maximum wt. post broken.	Deflection in inches.
D	.....458 lbs.	1,090 lbs.	0.68
B	.....648 lbs.	1,071 lbs.	0.70
A	......564 lbs.	1,020 lbs.	0.53
C	......927 lbs.	1,356 lbs.	0.66

The comparative results show the importance of thorough tamping and stiff reinforcement near the surface of the post. A cedar post of dimensions identical with the average of these concrete posts would weigh about one-fourth as much and be four times as strong. The results in practice show that the wood posts used are much stronger than necessary rather than that concrete posts are not strong enough.

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*Extract from report of Committee on Signs, Fences, Crossings and Cattle Guards to the American Railway Engineering and Maintenance of Way Association.

It has been reported in some of the western papers that the Hauserlake Dam, which went out about a year ago and is now in process of reconstruction, has been washed out again, and that a large amount of timber and parts of the finished work have been washed away with a large loss to the owners. The facts are that about 150 ft. of a temporary flume which had been built to carry the water around the site of the new dam has gone out, together with a small part of a diverting dam built to turn the water into this flume. The money loss is insignificant, the only effect of importance being that active work on the reconstruction will be postponed until after the high water in June or July.

Some Practical Ideas on Reinforced Concrete Design.*

BY ERNEST MCCULLOUGH†

My talk is to be on some things not mentioned in the current treatises on reinforced concrete design. Now it happens that an item often mentioned in specifications is that of deflection and none of the standard books say one word on the subject.

DEFLECTION

It is common to see rigid specifications for deflection, that is, the architect believes them to be rigid, whereas the manner of wording the deflection clause shows the reinforced concrete designer that he has been some one easy with whom to deal. It happens that a deflection of 1/360 of the span will not crack plastering so that very often we see a clause to the effect that the deflection under test load must not exceed 1/360 of the span. From this amount, it ranges to 1/1,500 of the span.

Now as it happens, this matter of deflection is one not yet settled and one that experimenters have apparently considered as hardly worth notice. When a specification comes in setting the amount of allowable deflection, we have to be pretty careful in our designing, for we only know in a general way that the deflection of a reinforced concrete beam is about one third that of a steel beam of equal strength and that a deflection that will crack the plaster on the under part of a beam or slab will undoubtedly be enough to permanently injure it. The elastic limit of the steel will have been long passed and the concrete will be on the verge of failure. Some architects go even further, however, and call for loads that will destroy the slab. Here is a copy of a specification that came into our hands one day lately:

> Before wood top floors are put on, the reinforced concrete floors must be subjected to a test in the presence of the superintendent. This test will be made by the contractor and will consist of loading any or all, parts of the floors, as the superintendent may designate, with a dead load of three hundred and fifty (350) pounds per square foot. When this test is applied should any part of the reinforcing system fail, crack, sag or unduly deflect, the entire system will be rejected and the contractor required to take out the entire system and rebuild until a satisfactory test is had.

The foregoing specifications were for a school house. A proper safe superimposed load per square foot for that building would have been 80 lbs. per sq. ft. Assuming a dead load of 40 lbs., a proper test load would have been twice the live load plus once the dead load, or 200 lbs. per sq. ft. Such a test load should have stressed the steel to not more than 90 per cent of the elastic limit and the concrete to not more than three fourths its ultimate strength.

The test load called for should have been sufficient under many systems of designing, to have brought the floors to the verge of failure and yet the deflection would not have been sufficient to have cracked the plaster. Notice also how indefinite the provisions are. If the floor deflects unduly then the contractor must take it out. Suppose the architect when he drew these specifications, had in mind a deflection of about 1/400 the span. Suppose that some reinforcing company had prepared plans for the contractor for nothing and had figured the sections so light that a deflection of about this amount would be secured. Suppose that in the meantime before the test is made that the architect had been informed by a disappointed bidder as to what he should expect and then imagine the result when the contractor has to take out the floors and rebuild them because of excessive deflection under test load.

Being an engineer for a reinforcing company and having many designs coming into the office, it has been a matter of interest to me to draw out some of the men whose plans were sent to our office. Whenever a set of specifications came in with a deflection clause we wrote to the architect asking for the formula by which he computed the allowable deflection. We told him that this was one of the unsettled points in reinforced concrete design and therefore wanted to know his method of figuring the matter in order that we could design to meet his requirements. The majority of the men never replied to our letters. A few, however, wrote and told us that they knew nothing about it and had supposed the deflection for a steel beam should be about right.

We platted the results of all published tests and tried to obtain a good formula, but the results were too discordant. The subject of deflections seemingly did not interest American experimenters. European experimenters did pay attention to this matter and it is easier to work after them. Professor Maurer of Wisconsin State University permitted me to copy a deflection formula he has lately developed as a result of his study of European beam tests, but I do not feel at liberty to give it here without his permission. It agrees very closely with loads up to one-third the ultimate and should be extremely useful when he has finished working on it. The only other guide we have is a formula proposed by Mr. Eli White in the "Engineering Record" for Nov. 9, 1907, [illegible] the subject of deflection [illegible] one.

Mr. White first ascertains the position of the neutral axis and considers it as midway between the actual reinforcement in the bottom of the beam and an equal amount of imaginary reinforcement placed wholly outside the beam. After all the transformations and substitutions rendered necessary to get it into agreement with ordinary deflection formulas, we finally obtain:

$$\text{Deflection in inches} = \frac{f_s l^2}{M\,d\,(1-k)\,30000000}$$

in which

f_s = fiber stress in the steel under assumed loading

l = span in inches

d = effective depth from top of beam to center of steel

k = depth of neutral axis from top of beam

M = multiplier = 9.6 for uniformly distributed load on beam freely supported at both ends

= [illegible] for partially constrained beam

= 18 for fixed or constrained beam

This method is only closely approximate and gives a deflection somewhat in excess of the actual deflection under load. When the specifications call for a test load and a certain deflection under the load it would be well to find the steel stress under the test load and then use this formula in order to know in advance what to expect.

An architect has a perfect right to call for a deflection not exceeding 1/1,000 of the span under a test load consisting of twice the live load plus once the dead load, thus securing as an actual test load twice the estimated load the slab or beam will ever be called upon to carry.

Testing my designs by the above formula we found in three instances that the deflection limit set called for much more steel than we really required and on taking the matter up with the men for whom the plans were wanted they readily agreed to leave out the test load and omit the deflection clause provided we gave them the detailed calculations for the work and took our oath that they were actually the calculations for the structure, and referred them to books where the formulas could be found.

Yet with a proper check upon design, such as is given by an intelligent requirement for deflection, it may be possible to give a much better shape to a beam than would be given under the ordinary rush conditions existing in a competitive designing office.

FACTOR OF SAFETY

Another thing found in specifications is a factor of safety clause. It is easy to write that the work as designed shall have a factor of safety of four and the requirement is common. Nine times out of ten we find that the man who prepared the specifications means that the floor should be able to carry four times the specified live load.

To an engineer a factor of safety implies the quotient obtained by dividing the ultimate strength of the material by the fiber stress allowed. That is to say if the steel

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has an ultimate strength of 64,000 lbs. per sq. in. in tension we have a factor of safety of four when we stress it only 16,000 lbs. per sq. in. The man who prepares the specifications will tell you he means just that also, but if you put up to him a floor weighing 150 lbs. per sq. ft. to carry a live load of 100 lbs. he will begin to hedge. Assuming a dead load of 150 lbs. and a superimposed safe load (live load) of 100 lbs., the total is 250 lbs. per sq. ft. and four times this is 1,000 lbs. The man who prepares the specifications will be perfectly satisfied if the floor can carry an ultimate (breaking) load of once the dead load plus four times the live load, or a total of 550 lbs. per sq. ft.

Much of the designing done today does not take into consideration the disproportion of dead to live load in reinforced concrete structures and happenings such as that just mentioned are common. Here is a table put out by a company manufacturing reinforcing material. Along the top we find the spans. On the left is a column giving the thickness of the slab and the weight per square foot of the slab. Underneath the spans we find the load per square foot that can be carried by the slab. In this particular case we find that the slab on a span of 19 ft. will carry only 7 lbs. per sq. ft. The slab is 7 ins. thick and the weight per square foot is 88 lbs. The calculations were made for a factor of safety of four, so we can add the live load and dead load together, which gives us 95 lbs., and multiply by 4 to get the breaking load, which amounts to 380 lbs. Substracting the weight of the slab, 88 lbs., we have left 292 lbs. per sq. ft., and dividing this by 4 we have a live load of 73 lbs. per sq. ft.

Remember that this is perfectly correct if we consider that it is safe to design floors to carry their own weight plus four times the live load, as an ultimate breaking load. If a factor of safety of four means this, then you see what can be done. If, however, the factor of safety of four means the materials are stressed to one-fourth their ultimate strength by the sum of the dead and live loads, the example just given is bad.

I have stated that 95 per cent of the buildings designed in reinforced concrete today have been designed with the benefit of the manufacture of reinforcing material in mind rather than with the benefit to the owner as a paramount consideration. Not five per cent of the reinforced concrete buildings are designed in the offices of the men whose names appear upon the plans and drawings. One reason is that the average architect does not have calls enough for this class of structures and therefore does not attempt to design the reinforced concrete work. He simply makes the plans for the buildings and prepares the specifications. He either has some reinforcing company prepare the plans for nothing or draws his specifications so that all systems have a show and the contractors have the plans prepared by the companies from whom the reinforcement is purchased.

Another reason is that very many men, while presumably competent, do not care to waste their time, for they feel that some salesman representing some special system of reinforcement will try to make the owner switch over from the plans prepared by the architect. A third reason is that the wise architect considers himself in pocket if he leaves the designing to the numerous companies so ready to do the work at no cost to him or the owner, in the hope of selling their material. Therefore it is customary to have a clause in the specifications to the effect that:

> Contractors bidding on the reinforcement will be permitted to bid on any system desired and must submit with their bids full drawings and computations, in order that the architect may check the work, etc., etc.

Then follows a few little things to guide the designers. It happens very often that the specifications do guide some of the designers so they know the man with whom they have to deal can be given anything they feel like giving him. It is seldom we get in a set of specifications that indicate much intelligence on the part of the writer so far as they relate to reinforced concrete. Occasionally some specifications come in that show the man who prepared them was thoroughly up to date, but such a man generally has his plans fully drawn and no good changes can be made. It is seldom that any special system of reinforcement gets in on such a man's work, for his own design is usually as economical as any that any contractor can obtain.

Generally, however, the architect simply prepares the plans of the building and everything connected with it except the reinforced concrete work and permits contractors to submit plans of their own for that. These plans are obtained by the contractors sending blue prints to reinforcing companies and asking them to submit bids for the reinforcement, together with blue prints showing how they propose to do it. The time given the reinforcing company in which to do the designing is usually from one to three days, the latter being quite a liberal time, and the engineers who have the designing to do feel quite grateful to a contractor who will permit them to work three days on the designs. By days we mean days of about eighteen to twenty hours each. We have worked three days on plans that should properly have taken three weeks' time. It is hardly to be expected that niceties of detail can be indulged in very much under the circumstances, but every engineer remembers that each of his competitors is also at work, so he must design as economically as possible if his employer is to get the work. If he forgets to multiply by two or three his firm of course stands a better chance to secure the job, but it means many weary, head-achy hours of skinning afterwards so there will be no loss and so the architect will not discover any great discrepancy between the preliminary plans and the final drawings.

It is a miserable system, but there is no hope of getting away from it. The only thing we can do is to teach men how to write proper specifications so the owner will be protected and so honest manufacturers will be protected against men who will skin to save a dollar. No, even to save a dime. So every firm has tables and diagrams to shorten labor and make the designing as nearly mechanical as possible. After all it is merely clerical work when one comes to think of it.

Before I end I will give you some specifications so that the man using them should come somewhere near to obtaining uniformity of design in plans he sends out for competitive bidding.

I propose to take up a typical building floor and go through it in several ways to show how different designers will tackle the work and thus show how an architect can easily be puzzled to select a system and at the same time avoid being charged by the owner with having been bought up, in case he selects a system that is not the lowest in cost. It nearly all hinges on the proportion of dead to live load and on the meaning of the term "factor of safety."

The floor selected is to be 100 ft. long and 50 ft. wide. The owner is prejudiced against tile and will not permit its use, even in combination with reinforced concrete, thus not allowing any lessening of dead load, such as is effected by tile when set in floors of ribbed design. The owner has been talked into the use of long spans, but does not realize how much this means in the item of increased weight, which means larger columns and heavier foundations as well as larger beams and girders. This also means that the steel and concrete are unduly stressed carrying their own weight.

The specifications fix the live load (safe superimposed load) at 100 lbs. per sq. ft. It is also stated that the factor of safety shall be four. Nothing is said about the fiber stress in the materials. The blue prints of the building, together with the specifications go into the hands of the contractors and six companies get an opportunity to bid on the reinforcing material. As the architect has spaced his columns 16 ft. 4 ins. on centers and will permit only two girders lengthwise of the building and will not permit any beams it is necessary to make slabs from side to side.

The conditions are such that we should really use for bending moment $\frac{wl^2}{10}$ for the two outside spans and perhaps $\frac{wl^2}{12}$ for the inside span. However, all the designers know that each of the others is going to figure as small a bending moment as possible so all will use $\frac{wl^2}{12}$. We are here considering that the men doing the work are not very bad men, or they might use $\frac{wl^2}{16}$ as I have known a great many to do. So in this competition we will consider them all alike in their assumption of bending moment conditions and we will take it for granted they will all use a ratio of deformation between steel and concrete of 15. As a matter of fact they will not all do it, but we must get somewhere on a common ground.

Table I shows all the conditions in detail, so we will consider them one by one. One designer who wants to be honest assumes for his weight the sum of the dead and live loads and after several trials gets a slab 7 ins. thick. He assumes a fiber stress of 16,000 lbs. in the steel and of 700 lbs. in the concrete. He uses the straight line assumption, which is best for buildings and the safest generally. The table shows the stresses he gets under the dead load only, as well as under the dead and live load. The cost of this floor (exclusive of form work) is $0.227 per sq. ft. The weight of a square panel is 23,400 lbs. to be carried by each column.

TABLE I.

Case	Thickness of slab	Wt. slab lbs. sq. ft.	Depth to center of steel, ins.	Depth to neutral axis, k	Moment arm, j	% Steel ratio	% Steel area sq. ins.	Steel fiber stress. Dead load only	Steel fiber stress. Dead and live load	Concrete stress. Dead load only	Concrete stress. Dead and live load	Cost per sq. ft. (excl. of forms) Steel	Cost per sq. ft. (excl. of forms) Concrete	Cost per sq. ft. (excl. of forms) Total	Weight of slab in sq. panel
1	7"	87.5	5.88	.398	.867	.0087	.512	7,500	16,000	328	700	$0.052	$0.175	$0.227	23,400
2	5½"	67.8	4.33	.414	.862	.0097	.500	8,200	20,000	384	940	0.049	0.138	0.187	18,350
3	5½"	67.8	4.5	.427	.858	.0107	.578	6,850	17,700	344	896	0.059	0.138	0.197	18,350
4	6"	75.0	5.0	.599	.775	.02	1.20	3,560	8,350	122	278	0.122	0.15	0.272	20,000
5	4½"	56.3	3.33	.584	.781	.0183	.731	6,590	19,050	403	1195	0.074	0.116	0.19	15,000

On the straight line theory it is absolutely wrong to figure ultimate values in steel and in concrete, yet it is often done. The second man multiplies his live load by four, adds the dead load and uses the ultimate strength of the steel, 64,000 lbs. per sq. in., and the ultimate (assumed) strength of the concrete, 3,000 lbs. He gets a fiber stress of 20,000 lbs. in his steel under the dead and live load and a fiber stress in his concrete of 940 lbs. The cost of this floor, without form work, will be $0.187 per sq. ft. and the weight carried to each column will be 18,350 lbs.

The third man does not believe in figuring ultimate values on the straight line basis, yet he does not like to figure in all his dead load. He therefore assumes a fiber stress of 16,000 lbs. in his steel and 800 in his concrete, takes half the dead load, plus the live load, and gets an actual stress in his steel of 17,700 lbs. and in his concrete of 896 lbs. under the combined dead and live load, instead of the fiber stresses assumed.

The fourth man is a college boy, just out of school and very anxious to do things so right. He assumes four times the sum of the dead and live load and uses the parabolic theory of stress. His assumption for the steel is based on the steel being stressed to two-thirds the elastic limit and the concrete to two-thirds its ultimate strength. The elastic limit of the steel is 60,000 lbs., so he uses 40,000 lbs. The ultimate strength of the concrete he assumes at 3,000 lbs., so he uses 2,000 lbs. An examination of the tabulated results will show how much chance he has to win out in a contest for competitive designs.

The fifth man is wiser and designs also by the parabolic method, but assumes the ultimate strength of the steel at 64,000 lbs. and the ultimate strength of the concrete at 3,000 lbs. He assumes once the dead load plus four times the live load. The table shows the results obtained.

It may be stated here that the parabolic theory calls for more steel than the straight line theory, so that the steel and concrete theoretically should fail together. The straight line theory gives a more rigid construction and therefore better for moving loads, while the excess of concrete permits some deflection to show long before the points of ultimate failure is reached.

Now there might have been some other common assumptions mentioned. Sometimes the specifications call for a test load. If this load is ridiculously low, as it often is, then the designer will pay no attention to the live load requirements and will ignore the factor of safety clause. You will find him designing so the test load will stress the steel to about 95 per cent of the elastic limit and the concrete to about three-fourths its assumed ultimate strength. Sometimes the designer will ignore the elastic limit and design so the test load will stress the steel to three-fourths of its ultimate strength and the concrete to about 95 per cent of its assumed ultimate strength. Instances have been known of some panels being specially constructed for the test load and in some way during the progress of the work the superintendent will have his attention directed to that panel in a manner that will make him select it as the one to be tested.

While the foregoing assumptions give [illegible] food for thought remember that we have not gone far from a common stress in the steel whereas designers are very free in their stress assumptions. I have had to check over plans where the steel stress was over 30,000 lbs., although the specifications called for half of that, and where the concrete stress was over 2,000 lbs., although the specifications set 600 lbs. as a limit.

I have had to check over plans where the architect specified fiber stresses of 16,000 lbs. in the steel and 650 lbs. in the concrete with a ratio of deformation of 15, where the man who secured the contract took the dead load plus four times the live load, divided them by four and then used the stresses called for. The live load in one case I remember was 100 lbs. per sq. ft., but under the assumptions made by the designer the live load was only a little over 30 lbs. per sq. ft. when these stresses were reached, for the dead load was high.

The only way to get good honest competitive designing is for the architect to state exactly what he wants and see that he gets it. To get away from the dishonest and ridiculous habit of assuming a slab to weigh only half what it actually weighs there should be a clause to the effect that the floor and beams supporting it should weigh not to exceed two-thirds the live load and preference will be given to the plan providing a floor that weighs not to exceed one-half the live load. Then when the designer gets to work he will add 50 per cent to the live load and correct for span.

Let

W = total load on the span, per foot width

l = span

M = bending moment = resisting moment = Rbd^2

then $l = \sqrt{\frac{8M}{W}}$ for freely supported beams or slabs

$l = \sqrt{\frac{10M}{W}}$ for partly constrained slabs

$l = \sqrt{\frac{12M}{W}}$ for constrained slab

When the owner understands that with long clear spans he likes so well [illegible] and that they make a building not as rigid as one having short span floors and roofs and that the extra weight added means increased expense for columns, walls and footings, he can be led away from the present craze for long spans and no beams or girders. If he does not like the appearance of the beam work he can conceal it by putting in suspended ceilings, thus giving him a building easier to warm and allowing him better facilities for running piping and wires.

A strong thing in connection with this long span work in ordinary buildings is the reasoning observed. In manufacturing establishments and warehouses this has not been noticed much, but when the city has been carried out in ordinary buildings it has been annoying. In some cases the defect has been cured by hanging a false ceiling underneath the obnoxious solid floor and in cases false beams have been put in hallways.

The examples given are of a very simple case. The matter might have been quite different in appearance if we had selected a live load of more than 100 lbs. or of less than 100 lbs. There would have been quite a difference also if the spans selected had been different. The bending moment varies with the square of the span and not directly as the span.

The formulas by which the calculations were made are to be found in Turneaure & Maurer's "Principles of Reinforced Concrete Construction." In all cases the steel and concrete stresses tabulated have been figured by straight line methods. Case 4 involving the elastic limit and a percentage of the ultimate strength of the concrete was figured by the parabolic method to obtain *d*, *j* and *k* and the per cent of steel. Case 5, where the ultimate strength of both steel and concrete entered into the matter, was figured by Talbot's flexure formulas to obtain *j*, *k*, *d* and the per cent of steel. The reason for giving the steel and concrete stresses in the table according to straight line theory was that only working stresses were considered and up to about one-third the ultimate strength of the concrete the difference between the straight line and parabolic theory is small.

It is not so very long ago that nearly all practical superintendents of construction stopped all work directly over the beams where no bending moment exists and where there is no shear.

This is no longer done, for it happened the work stopped just where there is the biggest tangle of steel, and good joints were hard to obtain. Experiments were made and it was found that it is immaterial where the work is stopped so long as perfect joints are made. Some men stop in the center where there is no shear, but there the bending moment is a maximum. It is no doubt best to stop somewhere on the beam or slab where neither shear nor moment are a maximum or a minimum, but about where the matter will be equalized.

The slab on top of a beam might readily be used as a part of the beam, thus giving us what is called a T beam section. Owing, however, to the joint trouble many engineers objected seriously to T-beams. Now, however, that we can make joints anywhere it is best to use T-beams in all cases, provided they are poured at the same time as the slab.

The first thing to select in a T-beam is the depth, as this is often a big factor in head room, etc. Having selected the depth we can figure out the width. If the slab is not less than one-fifth the total depth of the beam assumed, we can make a T section of it by having the narrow stem just wide enough to contain the steel. The amount of steel is the percentage obtained by the assumed depth multiplied by the width found. Thus, while the steel percentage might be about 1 per cent, still compared with the size of beam actually obtained it might be 3 or 4 per cent.

The width should not exceed one-third the span of the beam and should not exceed eight times the thickness of the slab plus the thickness of the stem enclosing the steel.

Thus we see the ordinary beam formulas may be used for designing T-beams. Turneaure & Maurer give an excellent treatment of T-beams. The tests of Professor Talbot showed that practically no limit can be set for width except that the wider the beam the greater the deflection and of course the question of shear is very important where the slab and stem join.

I recommend the following specification as one to recommend to architects when sending out plans for competitive designing:

Designers for the reinforced concrete portion of this building shall be held strictly to the following specifications:

The ratio of deformation between steel and concrete shall be 15. The steel fiber stress shall in no case exceed one-third the elastic limit of the steel and a maximum fiber stress shall be 20,000 lbs. per sq. in., even if this limit is less than one-third the elastic limit.

Concrete in beams and slabs shall be stressed in the most remote fiber from the neutral axis not to exceed the following: The best broken stone or washed gravel concrete mixed with one part Portland cement, two parts clean coarse sand, four parts clean broken stone or washed gravel, not to exceed 750 lbs. per sq. in. Such concrete tested in 12-in. cubes at the end of 28 days must show a strength of not less than 2,500 lbs. per sq. in. Concrete made of ready mixed bank gravel or of a 1-3-5 broken stone or gravel and testing not less than 2,000 lbs. in 12-in. cubes at the end of 28 days can be used with a fiber stress of not to exceed 600 lbs. per sq. in. Cinder concrete made of a one to seven mixture of clean washed screened cinders can be designed with a fiber stress not exceeding 250 lbs. with a ratio of deformation between the steel and concrete of 30. Concrete in columns reinforced with longitudinal rods or bars shall be stressed not to exceed 500 lbs. per sq. in. Columns reinforced with wire or fabric having the same hooping effect as wire may be designed so the concrete may be stressed in compression not to exceed 1,000 lbs. per sq. in. No column reinforced only with longitudinal rods or bars can contain more than three per cent of reinforcement. There shall not be more than 5 per cent of longitudinal reinforcement in wound or hooped columns and the wrapping or hooping shall never be less in amount than the longitudinal reinforcement. Columns reinforced with longitudinal bars or rods must have the same tied together at intervals not greater than their distance apart, with wire not smaller than a ten gage. No deformed or twisted steel can be used in columns. No columns can be made of cinder concrete. No broken brick or burnt clay will be permitted in reinforced concrete work unless it is used under the specifications for cinder concrete.

For one span slabs shall have a bending moment figured as $wl^2/8$. For two and three spans $wl^2/10$ and for more than three spans $wl^2/12$. Beams and girders shall never be figured other than as freely supported with $M = wl^2/8$. Panels perfectly square may be considered as having $M = wl^2/20$, but for panels having one side longer than the other and where the proportion of width to length is less than 1.5 may be calculated as follows: Let r = proportion of load carried by the sides.

L = length of panel.

B = breadth of panel.

$$\text{Then } r = \frac{L^4}{L^4 + B^4}$$

Having found the proportion of load to go each way use $wl^2/12$ to obtain bending moment. In all cases where the moment is figured for other than freely supported spans there must be adequate reinforcement provided for reverse bending moments at supports. All beams and girders must be reinforced over supports for negative bending moments. Proper reinforcement for internal and web stresses must be provided in all cases where such stresses may exist.

Safe superimposed loads shall be as per the schedule hereto attached. All the live load and dead load on the roof must be carried to the columns. For the first floor below the roof the dead load must all go to the columns, but the live load may be reduced 5 per cent. The live load on each succeeding lower story may be reduced an additional 5 per cent until a floor shall be reached where the proportion of live load carried to the column is 50 per cent and after which only 50 per cent of the live load on the floors below shall be considered as going to the columns.

Beams shall carry the full dead and live load, but girders may be designed to carry all the dead load plus 80 per cent of the live load except in storage warehouses.

Thirty days after the forms are removed the superintendent may have the floors, or any portion of them, tested with a load that shall be equal to twice the live load plus the dead load and after said load has been in place twenty-four hours the deflection shall not exceed 1/900 of the span.

If we could prevail upon all architects over the country to put these requirements into the specifications they send out, the effect upon reinforced concrete design would be beneficial.

Earth and Rock Section

Note: This Section is devoted to methods and costs of excavating earth and rock and building embankments. It will cover the grading of roads and railroads, diking and canal work, dredging, building reservoirs and earth dams, sewer and water pipe trenching, quarrying, etc.

Methods and Cost of Preparing Gravel for Ballast.*

PIT GRAVEL

The procedure in preparing gravel for ballast varies with the nature of the pit and the use to be made of the ballast. If a pit from which ballast is to be taken is submerged, obviously no stripping is necessary. If it is an upland pit, however, it is rarely wise to omit the removal of enough surface dirt to leave only material as good as the pit will furnish. When the conditions require gravel to be washed or screened it will still be found wise to strip most upland pits, as the surface dirt will interfere with the proper gradation of the material.

Stripping.—In general, the best method for removing the waste material is to use a steam shovel, loading the material into cars and using it to widen embankments. When the depth of stripping is too shallow to permit the economical use of a steam shovel, teams with scrapers can be used to windrow the strippings, using a steam shovel to load the windrows. The cost of stripping a gravel pit with a steam shovel, using the material to widen embankments, when the haul does not exceed 20 miles, should not be more than 15 cts. per cu. yd.

Loading.—A heavy steam shovel with a dipper holding from 2½ to 3½ cu. yds. makes a most efficient machine for loading gravel. Too great stress cannot be laid upon the advisability of having a shovel which has a large surplus of strength in all its parts, as economy in maintenance and in the operation resulting from lessening the loss of time occasioned by stopping for repairs, is very great. Center dump cars, which deposit the material where it can be used without any casting with shovels, are most economical, the larger the capacity of the cars the better.

In connection with the center dump cars, ballast spreaders mounted under a flat car are a necessity. The practice of placing a tie or like obstacle in front of the wheels, allowing them to skid while the ballast is being pushed out of the way, is a bad practice, resulting in flat wheels as well as loss of time in distribution of the ballast. Where only a small amount of ballast is to be handled, a device which will be mounted by the wheels and will itself slide on the rails can be used to good advantage.

Where only a very small lift or none at all is to be made, a great saving in time of applying the ballast can be made by the use of a distributing plow, which plows out the ballast close to the tops of the ties.

In most cases it will be found best to organize a crew at the pit in charge of an able, experienced conductor who will do all of the spotting of cars at the shovel, and, to a certain extent, take charge of the movement of the other trains in the gravel service to the various distributing points.

Cost.—It is impractical to give an approximation of the cost of preparing the gravel pit for operation, as local conditions will govern this entirely. The cost of loading the gravel depends upon three conditions: (1) The size and efficiency of the shovel. (2) The depth of the bank from which gravel is being loaded. (3) The supply of cars maintained under the shovel dipper.

As before stated, a shovel with a dipper having a capacity of 2½ to 3½ cu. yds. and designed with a large surplus of strength in all its parts makes a very efficient loading machine. Where the bank is 10 ft. or more in depth the greatest efficiency of the shovel should be obtained. Not less than four pitmen should be used, that no time may be lost in shifting. Where the bank is less than 10 ft. in depth it will generally be found that the frequent shifting of the shovel will materially reduce the output of gravel. It is assumed that the train service is sufficient to keep the shovel supplied with cars in order to make use of its full efficiency.

With the above conditions obtaining, from 2,000 to 2,500 cu. yds. per day on an average can be handled, the cost of which will be approximately $0.025 per yard based on the following rates of pay:

1 Train Engineman	$ 4.85
1 Train Fireman	2.75
1 Conductor	4.85
2 Brakemen	7.00
1 Shovel Engineer	4.85
1 Shovel Fireman	2.70
1 Cranesman	3.45
1 Watchman	2.10
4 Pitmen	7.00
Fuel, oil and waste, train and shovel	1.85
Total	$[illegible]

Distribution.—The length of haul regulates entirely the question of the number of trains and the number of cars to a train which should be used. The one hard and fast rule should be that the best of motive power be furnished for this service. Generally speaking, for hauls less than 10 miles one train in addition to the train at the pit is sufficient. Above 10 miles and under 30, two trains on the road will be sufficient. The only rule that can be stated is that, to get the most economical handling of ballast, to provide train service enough to keep the shovel well supplied with empties at all times. Where the haul is short the best practice is to put into one train only as many cars as can be handled readily by the engines which are assigned to that service. There is a decided loss on short-haul work where more cars are put into a train than can be dumped without difficulty by the engine.

When the haul is long all the cars should be given to a train that can be moved over the division, and enough set off on the siding nearest the distributing point to reduce the train to such size that the engine can readily handle it while dumping. This applies to center dump cars, where the movement of the train when being unloaded is very much harder than when on the road. In some cases it will be found economical to provide a train for the purpose of taking the loaded cars at the end of a long haul and unload them. It frequently happens that unforeseen delays occur during the unloading which will seriously cripple the through movement of the gravel trains, and on very long hauls the unloading train can be economically employed.

The cost of movement from the pit and distributing on the track depends wholly upon the length of the haul and congestion of traffic. The actual time consumed in distribution with center dump cars is immaterial, 30 minutes being sufficient time for the unloading of a train of from 100 to 500 cu. yds.

WASHED OR SCREENED GRAVEL

The essential features of a plant for this purpose are: (1) Positive separation of material into definite grades. (2) Capacity to furnish gravel in quantities sufficient for economical use as ballast. (3) Economical operation. (4) Economical disposition of the refuse, both boulders and fine material.

To fulfill the first requirement a plant must be so designed as to separate the material handled into dust, sand, gravel and cobbles or boulders. If these grades are not separated the proper proportion of sand and gravel necessary for the best results cannot be obtained.

In distributing ballast on track it is obviously necessary to produce the gravel in large enough quantities to permit the organization of the track forces on an economical basis. A plant which will produce gravel at a cost which would make it commercially profitable may be too small to produce ballast economically. That the screening plant must produce the gravel economically is obvious.

In the preparation of quantities of ballast there is necessarily produced a large amount of mud, sand and boulders or cobbles. To work successfully a plant must be so devised as to dispose of this rejected material. The stones should be run through a crusher and returned to the gravel for ballast, not only increasing the output, but improving the quality.

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*Extracted from American Railway Engineering and Maintenance of Way Association committee report on Ballasting.

Plants for the washing or screening of gravel naturally divide into two types: (1) Those for handling material from submerged beds of gravel. (2) Those for handling material from upland gravel banks.

The plant of the Union Sand & Material Co., South Memphis, Tenn., is a typical submerged gravel-bed washer, and the Lake Shore & Michigan Southern plant at Pleasant Lake is typical of the upland washer.

Union Sand & Material Co.'s Plant.—The equipment used to get this gravel from the river is a fleet of one tug and six barges, with a capacity of between 250 and 300 cu. yds. each; one dredge, with two 15-in. centrifugal pumps, each equipped with a length of pipe varying from 30 ft. to 75 ft., depending upon the depth of the water. These suction pipes can be moved horizontally and raised and lowered by means of a derrick with boom extending out from the front of the dredge. The two centrifugal pumps can load a barge in about one hour and ten minutes, and, as the average distance traversed from the barge to the plant is about 1½ miles, the tug is kept busy transporting the loaded and empty barges. Figure 1 shows a section of a typical plant.

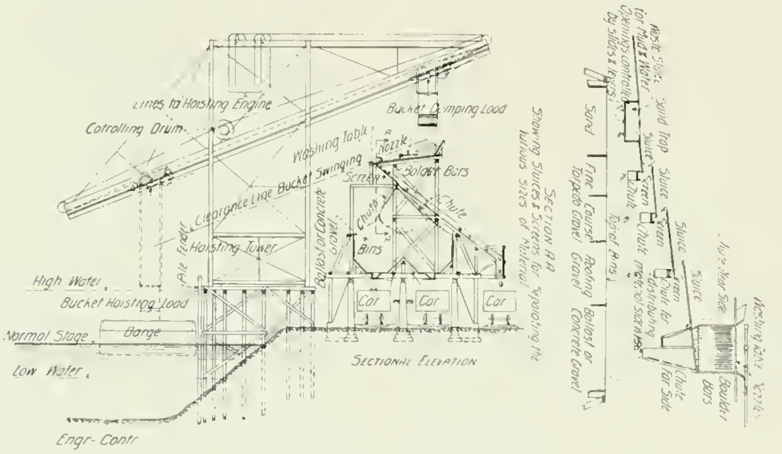

Fig. 1—Gravel Washing and Screening Plant.

The machinery on this barge was furnished by the Morris Machine Co. of Baldwinsville, N. Y. The dredge is about 130 ft. long, 30 ft. wide and heavy construction. The barges are 130 ft. by 30 ft over all.

The plant consists of two boilers, furnishing steam to an engine with 12½x16-in. cylinders. This engine furnishes power for running the plant, as well as pumping water to wash the gravel, of which about 1,500 gallons per minute is used.

The plant proper is built up on a network of creosoted piles, driven down well into the bank of the river. These piles are all cut off at the same elevation and have cribbing placed on top of them, upon which the plant has been erected. On the river side of the plant, where the four-leg tower has been erected, which supports the overhead carrier, there have been four clusters of piles driven under each leg. This overhead carrier hangs at an angle of about 30 degrees from the horizontal, the river end being the lower. At each end of this carrier there are a number of pulleys, upon which are operated the wire cables to handle the 5-yd. clamshell bucket.

The type of engine used to operate this clamshell bucket is the regular four-drum Lidgerwood. One man operates all the machinery connected with this bucket.

The river end of the overhead trolley system extends out sufficiently from the river to enable the clamshell to be lowered directly over the barge after it has been placed in front of the plant of the tug.

The overhead trolley system is placed at right angles to the river and the sand and gravel is transported to the bins by simply raising the clamshell until it comes in contact with the hook in the overhead trolley system. As soon as the contact is made with this hook, motion away from the river is commenced and the material in the bucket can be dumped at any point desired along the entire length of the overhead trolley, this being at the command of the engineer.

On the land side of the tower supporting the overhead trolley are built the bins for the receiving, washing and storing of the various kinds of sand and gravel acquired.

The gravel is dumped about half-way on the overhead trolley into a large hopper. At the bottom of this hopper is a gate; directly under the gate is a belt conveyor, which operates over concave rollers. In the concave belt is dropped the gravel by means of the gate. This conveyor runs at an angle of about 45° to the overhead trolley, and at its end is another hopper smaller than the first one, but worked in the same manner, over which all of the gravel is carried to a second belt conveyor of the same character as the first, which operates at right angles to the first conveyor and deposits the gravel as it comes from the barge into the chute, where the water is turned on the sand and gravel for the first time.

The gravel then is washed down various chutes and sluiceways and over different mesh screens to separate the finer gravel. As the gravel is separated by this different mesh screening, it is carried through by means of sluice boxes to the proper bin, and there deposited ready to be loaded into the cars at any time. This is done by simply opening the gates placed in the bottom of the bins, which are built sufficiently long and with a sufficient number of gates to load an average length car at one spotting. Figure 1 shows the arrangement of these screens, sluiceways and bins.

The waste water carrying the sand goes through a large box, which has an outlet near the top. This box has a movable bottom and as the sand goes into the box it is dumped directly into the bin.

The gravel turned out may contain any required amount of sand. That is, one kind of gravel used for roofing purposes is entirely free from sand and is supposed to go through a screen that has a mesh of ⅝-in. to ¼-in.

The gravel that goes through a screen from 1-in. to ¼-in. is called binder gravel, and is used for building purposes, where a clean gravel is required.

The gravel furnished for concrete purposes, where it has not been washed, usually contains from 25 to 45 per cent of sand, depending upon the order given.

The gravel furnished the railroad company for ballasting tracks contains from 25 to 35 per cent sand and is free from all large rocks or foreign material.

The track facilities consist of three parallel tracks, each of which extends sufficiently far beyond the bin to hold six cars. If only one kind of gravel is being loaded at a time, the tracks are of sufficient length to enable 30 cars to be loaded, but it is necessary for the switch engine to make a shift of cars.

The plant is operated by a superintendent, first and second engineer, blacksmith and helper, timekeeper and various help needed around the plant and on the barges. This force is exclusive of the forces employed on the tug and on the dredge.

The tracks, before they reach the plant, have been built up on a pile trestle for a distance of about 200 ft. In fact, all the tracks around the plant proper are supported by creosoted pile trestles.

On the river side of the plant there has been a pile breakwater built to protect the plant from the drift coming down at a high stage of the river.

The plant, designed by Brenneke & Fay, of St. Louis, cost, ready for business, approximately $140,000, and the life of it is expected to be 15 years.

The maintenance per year is figured at from 2 to 5 per cent of the first cost, the yearly maintenance varying largely on account of the varying conditions, as it cannot be calculated just what machinery will have to be replaced during the year.

Under favorable circumstances the capacity is from 2,000 to 2,500 cu. yds. of gravel per day of 12 hours. A barge of 200 cu. yds. to 800 cu. yds. can be unloaded in from 20 minutes to one hour.

The daily output of the plant is dependent upon good working conditions at the barge, good condition of machinery at the plant, and the switching facilities. An engine is constantly kept at the plant for switching, and the material is loaded into any kind of gravel or ballast cars.

Pleasant Lake Plant, Lake Shore & Michigan Southern Ry.—This company erected a plant in 1905 operated by electricity located at Rosel, a few miles south of South Bend, Ind. The company put up another plant in 1909 at Pleasant Lake, a short distance north of Waterloo, Ind. This plant is operated by steam. As this form of motive power is more general in availability, it is the one illustrated in this report. As the Rosel plant was the pioneer, the Pleasant Lake plant had the benefit of the experience gained there.

The gravel from the pit at Pleasant Lake is a fine gravel, mixed with more than some stone and boulders and a small amount of clay and loam. The object in washing the pit-run gravel is to remove all the clay and loam, to crush the stone and boulders for ballast and to separate the sand from the gravel, loading the sand in cars on one track and the washed gravel in cars on another track. The stripping is done by grading machines and the material wasted. The gravel is loaded by means of a 75-ton steam shovel using a 3½-yd. dipper. The loading face is 10 ft. The material handles well. It is loaded into 40-cu. yd. solid steel center dump ballast cars of 100,000 lbs. capacity. One hundred and twenty-five cars of this kind have been loaded as a maximum in one working shift of 10 hours, in which the shovel was actually working 7½ hours. Two engines and crews are used to spot the cars at the shovel, haul the gravel to the washer and dump same in the hopper there. The cars are hauled up a stiff grade.

The Pleasant Lake plant is a wooden trestle structure on concrete foundations. It is driven by a 200-H.P. Erie City engine. The water is supplied for the washer and engine by a Worthington 10-in. single-stage centrifugal turbine pump rated at 2,400 gals. against a 90-ft. head. The pump has a 10-in. suction 750 ft. long and 12 ft. lift. A [illegible] 165 H.P. is required to drive the pump and 175 H.P. for operating the entire plant. About 1,750 gals. of water are used per day in actual operation. The conveyor for the pit run or raw gravel was furnished by the Link Belt Co. and has a maximum capacity of 5,000 cu. yds. per day of 10 hours. The gravel is elevated [illegible] and is discharged together with the water for washing on a flume 6 ft. wide and [illegible] ft. long. The water is allowed to remove stones as they pass through a "grizzly bar" screen. The flume discharges on a flat screen with a 2-in. spacing and a ¾-in. mesh wire screen along and parallel to it. The bar screen removes all stones and boulders, which at once pass to a Gates cone crusher, where the stones are all crushed small enough for ballast and returned to the bar screen again until all passes through into the ballast, thus improving the quality of the finished output. The materials having passed through the bar and ¾-in. screen pass successively over or through a 3/16-in. and ⅛-in. mesh, respectively. The gravel passing over these screens passes to the ballast cars and the sand to sand cars. The separation of the water from the sand in these large quantities gave some trouble at first. The sand settles, as shown in the sketch side elevation, in a funnel with a valve at the bottom. The water and sand are admitted. The water flows over three sides of the square funnel and is wasted. When the funnel is nearly full of sand the attendant opens the valve and allows the sand to escape into the bin below. Only stationary screens are used; revolving screens have proven unsatisfactory. The maximum capacity of this plant is 4,000 cu. yds. of raw or pit run gravel per day of 10 hours.

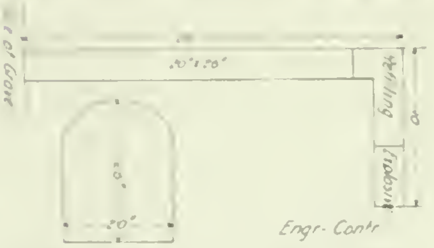

Fig. 2—Blasting Cementing Gravel.

About 40 men are employed. This includes one steam shovel crew, four train crews and several men calking cars with lath, shingles and hay to make them hold wet sand.

The cost per cubic yard of the washed gravel varies much with the percentage of washed gravel obtained from the pit run gravel. Some pits show 10 per cent, some 55 per cent of washed gravel. Others show 65 per cent, while some pits promise to show 90 per cent of washed gravel. The market for the sand has a considerable effect upon the net price of the finished product. Of course, the amount of stripping and the cost of the land are important elements. No general rule is safe, but it is not unreasonable to expect that pits may be found where the washed gravel would cost about twice as much as the raw or pit-run gravel.

CEMENTING GRAVEL

There are two gravel pits in the territory east of Memphis where cementing gravel is worked for the purpose of supplying ballast to railroads; one at Iuka, Miss., on the Southern Ry., known as the Tishomingo Gravel Pit, owned and operated by the Tishomingo Gravel Co. of Memphis, Tenn., and one at Perryville, Tenn., on the Memphis & Paducah Division of the Nashville, Chattanooga & St. Louis Ry., owned and operated by the Perryville Gravel & Ballast Co. of Memphis, Tenn.

As the character of the gravel and the manner of working the two pits are somewhat different, they will be handled separately.

Tishomingo Gravel.—This is a water-worn gravel lying in a compact mass requiring blasting before it can be handled with a steam shovel. It is composed of 20 per cent clay, 5 per cent sand, and 75 per cent gravel. The gravel as a rule is small and none of it is large enough to require crushing to make it suitable for ballasting purposes. In order to get it in shape to load with steam shovel, it is loosened up by blasting. This is accomplished by digging a tunnel about 20x26 in. in cross-section into the material a distance of about 20 ft., then turning at right angles for a distance of 10 ft. (see Fig. 2). This digging is done by a man lying down using a pick with a very short handle. The cost of digging this tunnel is 50 cts. per foot.

The charge is placed in the extreme end of the tunnel and a portion of it is refilled as shown on sketch. From 75 to 100 car loads of material is loosened up at each blast. This material is then loaded by steam shovel into cars. The cost of this material is as follows:

Loading, per yard	$0.09
Hauling, per yard	0.20
Unloading and distributing	0.07
Putting under ties and surfacing	0.11
Total	$0.47

The advantages of its use are: Small cost, quick cementing qualities, holds track in line and surface well under fairly heavy traffic, does not churn, very little dust and has great resistance to erosion by water. Considered an excellent ballasting material. Has the disadvantage of growing prolific crops of weeds and grass, making it costly to keep clean.

Perryville Gravel.—This is an angular gravel lying in compact mass requiring blasting before it can be handled.

Large pockets of clay are encountered, making it preferable to load by hand in order to get the best material. It is estimated at 10 per cent clay and 90 per cent gravel, with chemical analysis of 77 per cent silica, 15 per cent alumina and 6½ per cent iron. There is found in this pit considerable hard stone which has to be crushed before suitable for use. The cost of this gravel per yard is as follows:

F. O. B. cars at pit, per yard	$0.37½
Hauling, [illegible] per ton, per yard	0.25
Unloading and distributing	0.04
Spreading, putting under ties and surfacing	0.08
Total	$0.74½

Comments on Dump Wagons.

(Concluded from p. 259, April 7, 1909.)

We conclude our comments on dump wagons, first taking up the class known as special dumps.

The Turn-Turtle Wagon Co., of Indianapolis, Ind., are the manufacturers of the Turn-Turtle dump wagon. The wagon is made of steel throughout. The body, which is box shaped, with the rear end on such an angle as to admit of dumping, is pivoted on the frame and held in place by a catch. When this catch, controlled by a lever, is released, the body turns turtle automatically, thus dumping the entire load. The body turns clear over, so that there is no possibility of any material remaining in it.

The smallest size made, having a capacity of 40 cu. ft., is only 4 ft. 5 ins. high from the ground to top of body, and the wheel base is but 7 ft. 11 ins. The short wheel base makes the wagon light draft, while its low height reduces the cost of shoveling.

Any material that will dump by gravity can be hauled and dumped in this wagon, and as the load is dumped to the rear of the box, the dumped load cannot interfere with the movement of the wagon on the dump. In dumping asphalt, it is stated that the wagon dumps its load in a solid block, like a jelly mold, thus preventing the air from circulating through the mass, as is the case with asphalt dumped from other wagons. When it is desired to shovel part of the load from the wagon a snubbing device is furnished, for holding the rear point of the body level on the rear axle, allowing the men to stand on the ground and shovel with ease from the rear of the wagon. As the body is a solid box it is not possible for it to leak or spill any part of its load. The wagon is made in four sizes, 1½, 2, 2½ and 3 cu. yds. capacity.

Geo. H. Holzbog & Bro., of Jeffersonville, Ind., manufacture a dump wagon that could be classed under the head of a special dump wagon, but we have already described it, in this series of articles, with the end dump wagons.

The Tiffin Wagon Co., of Tiffin, O., manufacture a wagon known as the Four Bucket steel dumping wagon. This wagon has four compartments, each being a round bottom box, pivoted at the center, so as to be revolved in being dumped. These boxes are made of steel, while the rest of the wagon is of wood. On one side is a footboard for the driver to walk on in dumping. Each bucket or compartment can be dumped separately, or they can all be dumped at the same time. Each bucket holds one-half yard. The bed can be used on any ordinary wagon gear. Four different kinds of materials can be loaded and hauled at one time, or materials can be measured and proportioned in the buckets, thus the wagon can be used in feeding concrete mixers. The wagon was designed for hauling stone, gravel, sand, ashes or earth, and it is stated that it will do economical work in road building. The wagon can also be used for hauling wet garbage. The wagon has a wheel base of 7 ft., weighs 1,800 lbs., and has a height of 4 ft. 7 ins. from the ground to top of side.

The Bergen Point low body wagon is manufactured by the Bergen Point Iron Works, 149 Broadway, New York. This is not a dump wagon in the ordinary sense of the word, for there is needed a dumping machine to dump the wagon, hence we have classed it among the special dumps.

The principle of the construction of this wagon is to obtain a low body that can be filled at the minimum expenditure of muscular effort. The manufacturers claim that the power or energy expended in filling a wagon is the product of the load multiplied by the height of the top of the wagon above ground. Therefore, with the same expenditure of energy one of their wagons can be loaded in one-half the time that a wagon standing twice as high above the ground could be loaded; or, given the same time for loading, one of their wagons could be loaded with one-half the labor under the same conditions.

As the wagon is not required to clear its load after dumping, it can be built very low. The body is lifted off of the running gear by a dumping machine and dumped by being turned over. Thus the wagons are adapted for handling any material which has to be disposed of at a given point, provided sufficient materials have to be handled to pay for the expense of setting up a dumping machine. This would seem to make the wagon especially adapted for collecting city refuse, which often has to be loaded from large cans or boxes, and generally is disposed of at one or more fixed points, being so great in total volume that the cost of a dumping machine is relatively insignificant. The bodies of the wagons are made of steel, and as they are solid will not leak.

The Cator Dump Wagon Co., of Palmyra, N. Y., make both a dump wagon and a dump box, both being built on the same principle. This wagon might be called a side dump wagon. The running gear and frame work are made of wood, but the body is made of steel. A heavier and larger wagon is made entirely of steel with the exception of the wheels and tongue. The body is a rounded bottom steel tray that is trunnioned lengthwise and dumps by revolving, thus dumping the load from the side or top of body, yet dumping the material under the wagon. The load is dumped by means of a hand wheel in front of the drivers, acting on a bevel gear. The box being supported by trunnions enables the teamster to dump the load on either side of the wagon. A part or the whole of a load, it is stated, may be dumped in one place, or the load may be evenly distributed. By a tilting device the edge of the box may be lowered, making it much easier to be loaded by shoveling. The tray is built just like a boiler and is water tight. This makes it valuable for carrying wet garbage, concrete, mortar and similar materials.

As there are no doors to the wagon, the dumped load canot in any way interfere with the free movements of the wagon. The regular size of the wagon is of 1½ cu. yds. capacity, and weighs about 2,000 lbs. However, larger size wagons are also built. The wagon does not have a fifth wheel, there being instead a ball and socket joint which provides for plenty of rock and perfect freedom in turning under all conditions. The axles are made of steel. The portable dump box, built by this company, fits any wagon gear. As stated, it operates in the same manner as their dump wagon.

The Buffalo Pitts Co., of Buffalo, N. Y., make a side dump wagon or car. This wagon is meant to be pulled in trains by a traction engine. Mounted on broad tired wheels, it is built like, and greatly resembles, a two way dump car used on construction work, and run on rails. The side of the car drops down on hinges like a tail gate, and the car is tilted to an angle of 45 degrees, to deliver the load, the mechanism to accomplish this consisting of a train of spur gearing multiplied so that one man with a crank can easily operate it.

The box has a capacity of 12 to 15 tons over good roads. The car can be hitched at either end. The wheels are 40 ins. in diameter, 12-in. tire, ⅞ in. thick. The width across the outside of wheels is 6 ft.

The Russell & Co., Massillon, Ohio, also manufacture a side dump wagon for use with traction engines. This company makes either flat top, box bed, center, side or end dump wagons.

Two other wagons that may be considered as special dump wagons have already been commented upon in this series of articles. (See Engineering-Contracting, Feb. 17, 1909, p. 131 and 132.) One of these was the invention of George Perrine and D. L. Hough and is being used in building the Pennsylvania tunnel under Manhattan, while the other was invented by Wm. J. Newman and has been used on various work in the city of Chicago.

No matter what kind or style of wagon is used an important consideration in purchasing is the draft. Is it of light draft? This means not only increased loads and larger loads, but it also means the saving of horse flesh. Sometimes an empty wagon may be as hard to draw as a light draft, loaded wagon. The important features of a wagon to consider as to draft are the sizes of the wheels and axles, especially the skeins and the boxes of the wheels. The injury and breaking of either the skeins or the boxes of the wheels mean that the wagon will pull hard, so new skeins or boxes should be substituted at once.

The size and character of the fifth wheel affects the draft. Whether the wagon is to be operated in a city or in the country plays an important part with the character of the fifth wheel. This is also a consideration in selecting the kind of a tongue to be used. In the city in hauling over rough pavements with heavy loads, springs on the wagon lighten the draft.

A short wheel base gives light draft, and so does close coupling of the horses to the wagon.

For hauling in the country the tires of the wheels should always be wider than for city use, but even for country use the tires can be made too wide, when horses are used to draw the wagon.

All-steel wheels are now being manufactured and used on wagons. When these wheels were first put on the market the hubs were made of one solid piece; consequently when it became worn on the inside the entire wheel had to be discarded. Consequently some of the manufacturers have fitted the hubs of their all-steel wheels with inside boxes, which can be renewed as they become worn. The Bruner Steel Wagon Co., of Wapakoneta, Ohio, make an all-steel wheel of this kind. Their wheels are also made of sheet steel, cold pressed, being a solid wheel, instead of one with spokes and rim. This company also makes all-steel wagons.

Steel single and double trees and neck yokes for wagons are being used more and more each year. They are light and strong, and in the opinion of many teamsters and contractors have decided advantages over those made of wood, which are easily broken, or if made strong enough are very heavy. Many wagon manufacturers are equipping their wagons with these steel single and double trees and neck yokes. Two of the manufacturers of these trees and yokes are the Bruner Steel Wagon Co., of Wapakoneta, Ohio, and the Pittsburg Tubular Steel Whiffletree Co., of Pittsburg, Pa.

At different times there have been placed on the market wagon loaders that are meant to be attached to wagons, and as they travel load earth into the wagon. A machine that could be attached and detached quickly and stand up under its work would no doubt prove valuable, but, so far as we know, all those thus far offered for sale have been withdrawn from the market.

The Quick Unloading Car Chute, manufactured by the Quick Unloading Car Chute Co., of Birmingham, Ala., is a wagon loader. This consists of a dump box that is attached to the side of a gondola or hopper bottom car that has to be unloaded into wagons. The material is shoveled into these dump boxes or car chutes, and when one is full a wagon drives up under it, when the load is discharged into the wagon, without loss of time. This arrangement prevents the loss of time by the shovelers in waiting for wagons to be loaded and also of lost time while the horses are standing idle for the men to load the wagon. This device will no doubt prove economical in unloading sand, gravel, broken stone and other materials from cars. It was illustrated and described in ENGINEERING-CONTRACTING, Jan. 8, 1908.

Materials of all kinds are now being hauled in dump wagons, and there are many designs of wagons to adapt them for use for certain materials. Earth and rock, sand, gravel, crushed stone, concrete, asphalt, tar, mortar, garbage, ashes, wet sewage, manhole cleanings, snow, swill, coal, coke, grain, lumber, scrap iron, paving blocks, bricks, tiles, street sweepings, night soil and building materials are among the things now hauled in dump wagons.

Owing to many of these materials being wet and leaking through the doors of bottom dump wagons, the all steel end dump wagons with solid bottoms are used quite extensively for mortar, concrete, wet garbage, sewage and similar materials. When asphalt is hauled in wagons, the latter are generally lined whether of wood or steel, with an asbestos lining to prevent loss of heat and also to prevent the hot asphalt from injuring the wagon. Many wooden wagons are also steel lined to prevent wear on the wooden bodies.

All of the larger size wagons, and even some of the smaller ones, are now made with the sideboards on hinges so as to admit of the boards being lowered while the wagons are being loaded, especially when loading is done by hand.

A very important consideration in a dump wagon that is to be loaded by a steam shovel or by an orange peel or clam shell bucket, is the neck of the wagon. When a half cubic yard or a yard of earth and rock is suddenly dumped into a wagon body, a severe strain comes on the neck of the wagon, and it must be strong enough to withstand this, or else the wagon soon breaks, or at least the movement of the doors is interfered with by the strain brought on the neck.

Nearly all the wagons that have been designed for spreading have been built for spreading crushed stone on wagon roads, but they can also be used for spreading other materials as earth in layers and concrete on road and street work.

It might be said that the handling of materials in dump wagons is in its infancy, and the next decade will no doubt show many improvements in the wagons and the methods of handling them.

The sundry civil act passed by Congress carries an appropriation of $1,107,390 for the U. S. Geological Survey. The purposes for which this sum is to be used include the following:

Geologic surveys	$225,000
Topographic surveys	450,000

Recommended Practice for Handling Slides and Washouts on Railways.*

SLIDES.

(1) Every slide should be considered as a problem by itself.

(2) The cause of the slide should be sought. The removal or prevention of the cause is as important as the restoration of the roadway.

(3) Piles or retaining walls for the prevention and cure of slides are not recommended, but their use is permissible for temporary repairs and in special cases.

(4) Underground water should be drained away or intercepted before it reaches the slide.

(5) The surface of the slide and the restored roadway should be graded so water will run off and not lie in pools. The surfaces may be compacted or sodded.

(6) The flattening of the slope is the most economical and permanent method of curing a sliding embankment.

(7) The removal of the material is nearly always the most economical and permanent method of curing a slide in excavation.

(8) A relocation of the line is sometimes necessary where the slide takes the proportions of an avalanche.

WASHOUTS.

(1) The ends of trestles and bridges should be protected with riprap or by other efficient means.

(2) Main track should be raised above height of flood waters and carried on strong and stable roadbed so that it will not be subject to overflow.

(3) The track on an embankment subject to overflow should be ballasted with heavy angular ballast and anchored, and the lower slope of the embankment should be protected with riprap.

(4) On bridges subject to overflow the track should be anchored.

(5) If the velocity of the water carries away the riprap or other protection against scour, the width of the opening should be increased.

(6) If track is washed out temporary repairs should be made by filling in cribbing or driving piles, to be followed by the permanent restoration of the roadway.

SURFACE AND SUB-SURFACE DRAINAGE AND TILING OF WET CUTS.

(1) All the water possible should be kept off the roadbed.

(2) Intercepting surface ditches should be constructed for the protection of cuts.

(3) Intercepting ditches or pipe drains should be provided for the protection of banks built on saturated soils.

(4) Side ditches should be constructed in cuts through all classes of materials.

(5) Pipe drains should be provided for the drainage of wet cuts.

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*Extract from report of Committee on Roadway, American Railway Engineering and Maintenance of Way Association.

Roads and Streets Section

Note: This Section is devoted to methods and costs of road and street construction. It will cover road building in all its details, the construction of pavements, sidewalks and gutters, the testing and use of paving materials and the machinery and tools used in road building and paving.

The Theory of Economical Road and Street Design.

(I.)

Pseudoscientific Methods of Design.—Up to the present time it cannot be said that any correct and complete theory of the economic design of a road or street is to be found in any book. Pseudoscience there is in abundance, but the application of "judgment" in designing a pavement is the nearest approach to a scientific treatment of the subject. Judgment, however, can not be imparted. The possessor of good judgment is, in fact, the possessor of some of the elements of science, but they exist in such crude form in his brain that he is incapable of reducing them to a theory that can be taught. The opening sentence of this paragraph will appear to many as being an iconoclastic statement that can by no possibility be substantiated. Let us consider it.

In Baker's "Roads and Pavements"—one of the latest and best books on the subject—we find, on page 582 et seq., a discussion of the "relative merits" of pavements. Prof. Baker rates the "ideal pavement" as follows:

ECONOMIC QUALITIES:	Per Cent	
Low first cost	15	
Low cost of maintenance	20	
Ease of traction	10	
Good foothold	5	
Ease of cleaning	10	
Total		60%
SANITARY QUALITIES:		
Noiselessness	15	
Healthfulness	10	
Total		25%
ACCEPTABILITY:		
Free from dust and mud	10	
Comfortable to use	3	
Non-absorbent of heat	2	
Total		15%
Grand total		100%

There is an appearance of scientific treatment in such a tabulation that is very deceptive. This method of selecting a pavement is as illogical as it would be to choose a suit of clothes by assigning different percentages to the buttons, the cloth, the fit, the style and the durability. A study of the scientific method of designing a road or street will be the best way of disclosing the pseudoscience of selecting a pavement by any percentage rating of its different qualities.

The Fundamental Law of Economic Highway Design.—A road or street is primarily designed to reduce the cost of transportation of goods in vehicles. The secondary use of a highway is for the transportation of passengers, and of that secondary use we shall speak later. Let us take up first the economics of transporting goods over roads and streets. The unit cost of transportation may be divided into three elements: (1) Cost of hauling; (2) cost of maintenance of the highway; (3) interest on the first cost of the highway. Hence we have the following fundamental law of economic design of highways:

Design the highway so that the unit cost of transportation shall be a minimum, omitting from this cost none of the three elements: (1) Hauling; (2) highway maintenance, and (3) interest.

In applying this law or rule, there is usually more or less difficulty involved in ascertaining certain data, particularly the probable tonnage to be hauled and the rate of wages of team and driver, or, if autocars are used, the cost of maintaining the same. Nevertheless, even though absolute accuracy in estimating these elements may not be attainable, a sufficiently close approximation is possible of attainment.

An Example Showing Importance of Applying This Law.—In designing roads (including location as a part of the design), it is now customary to adopt certain standard designs which are used without much regard to the probable traffic that will come upon the road. Let us take an example that will show how erroneous such a procednre may be.

Assume that a macadam road is to be built to provide for a traffic of 100 team trips daily, 50 trips loaded and 50 trips returning empty, the load being 3 tons. Then the average load for each of these 100 trips is 1½ tons. Assume the wages of team and driver to be 35 cts. an hour. Assume the first cost of this proposed road to be $8,000 a mile, and interest to be 5 per cent. Assume the stone to be of a kind and cost such that the annual maintenance under this traffic will be $200. We then have the following annual cost of "operating, maintenance and fixed charges" per mile of road: The 100 teams will each spend 0.4 hour traveling the mile (the speed being 2½ miles per hour), or 40 hours daily, or 12,000 hours per year of 300 working days. At 35 cts. per hour, these 12,000 hours of hauling amount to $4,200. Since the 100 teams transport 150 ton-miles daily over this mile of road, we have 45,000 ton-miles per annum of road. Hence the cost of transportation is as follows:

	Per mile per annum.	Per ton-mile, etc.
Hauling	$4,200	9.33
Maintenance	200	0.44
Interest (5% of $8,000)	400	0.89
Total	$4,800	10.66

For comparison let us now assume the same road, but with a traffic exactly one-tenth as great, or 10 team trips daily. Then we will have:

	Per mile per annum.	Per ton-mile, etc.
Hauling	$420	9.33
Maintenance, say	30	0.07
Interest (5% of $8,000)	400	8.89
Total	$850	18.29

This shows strikingly the importance of ascertaining the annual traffic in determining the kind of highway to build. With the heavy traffic of 45,000 ton miles annually, we see that we are economically justified in doubling the first cost of the road, if, by so doing, we can add more than 10 per cent to the average load hauled by each team. With the light traffic of 4,500 ton miles annually, it is clear that no such expenditure as $8,000 per mile of road is justified.

The Data to Be Considered.—The first step that the highway engineer should take is to estimate the probable traffic that will come upon the proposed highway, for without such an estimate no scientific design is possible. We shall subsequently consider the methods to be persued in making such an estimate.

The second step is to fix upon an average cost of wages of driver, feed and maintenance of team and interest, repairs and depreciation of team and vehicle. This, too, will be discussed in detail.

The third step is to make a tentative design of the highway and an estimate of its first cost per mile, from which the item of annual interest can be derived.

The fourth step is to estimate the cost of maintenance per mile of highway. Under maintenance we include: (1) Current repairs; (2) cleaning; (3) sprinkling, and (4) the sum annually set aside to provide a fund for rebuilding the pavement when entirely worn out—amortization fund allowance.

The first step is to summarize the unit cost items ascertained from these data, as above indicated.

The sixth step is to make other tentative designs, and from them derive other unit costs of transportation.

The final step is to select the design that shows the lowest unit cost of transportation.

Obviously this process is by no means as simple as the process of drawing up of a few "standard designs" to be used almost regardless of traffic conditions. Yet any other process of highway design is unworthy of being classed as scientific.

(To be continued.)

The Degnon Contracting Co., New York city, has been awarded the contract for constructing the Wallkill siphon for the Board of Water Supply of New York city. The contract price is $4,982,726.

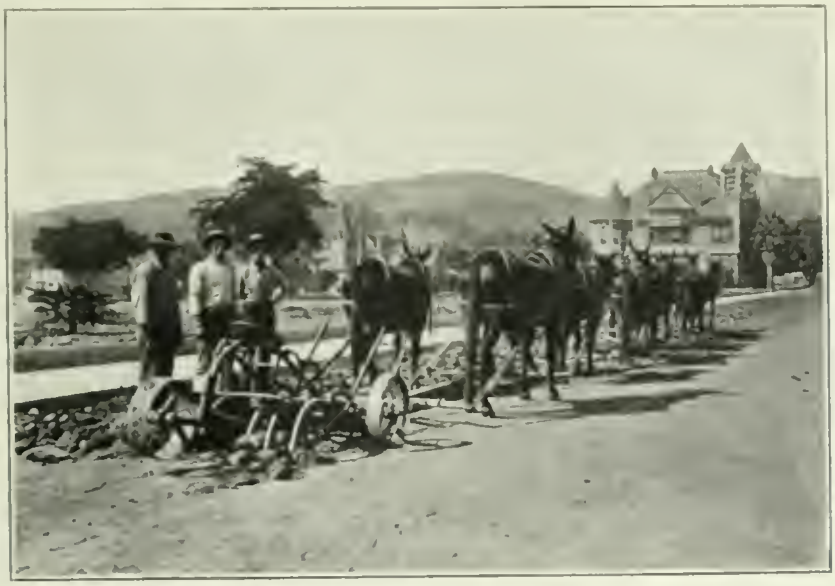
According to press dispatches the forces working on the Jawbone Division of the Los Angeles Aqueduct made a distance of 370 ft. in each of the two tunnels during the month of March.

Economic Handling of Teams with a Jerk Line and the Use of a Gang Plow on Road Construction.

BY W. A. GILLETTE.*

My experience in construction work in most every part of the United States has given me an opportunity to study methods as well as costs.

I have been especially impressed with the difference between the extreme West and East in handling teams. When I did construction work in the East I did as Easterners do, namely submitted to the dictation of teamsters in the determination of each driver to drive his own team. Consequently, when we wanted to use three or four teams on a road grader or plow, three or four teamsters walked along, not driving but "herding" the teams. Once in a while we could find a man who could drive four horses, but not often; and when he knew how he wouldn't do it.



Petrolithic Gang Rooter Plow for Hard Roadway.

Consider what it means to a contractor to have three extra drivers on a plow, drawn by four teams and two extra drivers on a road grader drawn by three teams. It is just as ridiculous as having two men loading wheel scrapers. Five extra men on an outfit as mentioned above means $7.50 a day, drivers' wages being $1.50 a day.

In the West we use one driver for one, two, three, four, five or more teams, and these drivers will handle three, four or more teams with one rein or jerk line with as much ease as the ordinary driver handles one team. It is a comparatively simple matter to train these teams to respond to a jerk line, and to the shout of "gee" or "haw."

For the benefit of those who do not know how to hitch a jerk line, I will explain. It is customary to use a strong braided clothes line. This line reaches from the "nigh" wheel animal to the "nigh" lead animal, and is fastened to the left hand side of the bit; from the main line a short piece of the line passes under the jaw to the right side of the bit, making a "Y." Fastened to the hames on the right side of the "nigh" lead is a "jockey stick" (a short piece of wood or iron) which reaches to a jerk strap fastened to the bit of the "off" lead animal. A straight pull on the jerk line pulls the "jerk" line or "nigh" animal to the left, or "haw," and the "jockey stick" guides the "off" animal. A succession of jerks on the line causes the "nigh" or left lead animal instinctively to throw its head to the right, to escape from the jerking, and the "jockey stick" guides the "off" animal to the right also, or "gee."

A little patience will teach the lead team to "gee" or "haw" if the guiding words "gee" or "haw" are shouted every time the line is used. By fastening the following teams to the double trees of the team ahead, they will soon learn to follow the team ahead without being tied, and, as a matter of fact, it is not as handy in turning around if each team is fastened, as it does not permit them to cross over and out of the way of the chain while turning.

When a team has been properly trained in turning to the right or "gee," for example, the teams following the lead teams will step over on the left of the draft chain and follow it around until the chain is straight for the return trip, then each animal will cross over to his place on the right side of the chain.

The accompanying picture shows a 12 mule team on a gang rooter plow. This team and plow are managed by a driver and a plow man. The plow shown in the picture is the most valuable tool for road work I have ever seen. It is composed of a set of five rooter plows mounted one foot apart on a frame, so arranged as to permit the setting of the plows at any required depth. It is especially adapted for breaking up old macadam roads or very hard ground. One striking feature is that a plow holder is not absolutely necessary, as it is possible for the driver to control the raising or lowering the plows by means of levers, and the furrows are as straight as the driver guides his team, and the ground is broken more thoroughly than with any other plow; no hard spots are left to cause trouble in loading scrapers or shoveling, or to interfere in the use of a road grader.

When it is used for breaking up old macadam roads for resurfacing, and for this class of work it is especially desirable, it is possible to set the plows so they will break the surface and not disturb the solid base. It is so constructed as to permit its being weighted with stone or pig iron.

This gang rooter is patented and manufactured by the Petrolithic Pavement Co., of Los Angeles, California.

In all of our team work we use but one driver, no matter how many teams are hitched to the load. In the hauling of gravel, sand or broken stone we use two or three wagons in a train. The trail wagons have a short trail tongue just long enough to permit the wheels to clear about three or four feet. The economy of this method of teaming is apparent when one driver is used to handle three wagons with three teams, for the wages of two teamsters are saved.

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[*] 764 Pacific Electric Bldg., Los Angeles.

The Use of Tar, Oils and Emulsions on Macadam and Earth Roads.*

A. R. HIRST.†

Until recent years a well built macadam road composed of two courses of stone or gravel with the dust or other binding material necessary to fill the voids well rolled and well drained was a very satisfactory and economical pavement for light traveled and comparatively satisfactory for heavily traveled thoroughfares. But the advent of the automobile traveling at high speed has such a disastrous effect on macadam roads as commonly built that the highway engineer has been forced in many cases to either abandon macadam as a form of construction or to adopt some means of protection for its surface.

The subject of dust prevention is the subject of macadam road maintenance expressed in different words. If no dust is formed there is no wear, and the nearer we can get to this theoretically perfect condition the longer our roads will last. If the speed of motor cars could be kept within the limits assigned by law very little damage would result from motor traffic. It has been demonstrated that the shearing, sweeping, ravelling effects of motor cars does not attain dangerous proportions until the speed reaches 20 or 25 miles an hour, and that above this speed the effect increases faster than the velocity. There seems to be no way by which the excessive speed can be checked and therefore the only thing to be done is to guard as far as possible against the effects.

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[*] Abstract of a paper delivered at the recent meeting of the Society of Wisconsin Engineers.

[†] Highway Engineer Wisconsin Geological and Natural History Survey.

One of the best dust preventatives is proper construction. Only good hard stone should be used in the top course of macadam. The use of soft limestones and sandstones should be avoided. The wearing coat should be hard and tough if the best effect is to be produced. We believe that road engineers should give more attention to the selection of top course material and try to pursuade their employers to count rather upon ultimate economy than on first cost. The nearest material to the work is not always the most economical. It is often better to pay $2 for granite than to get limestone for $1.25. If better stone is used less preventative measures will be necessary, though even the best stone surface will produce too much dust for comfort if left to take care of itself.

The first of the dust preventatives proper is plain water. This has been used since the time of Adam to lay dust and in the hands of the Almighty it is a very effective agent, but in the hands of man it is an expensive method. Salt sea water is now used on the coasts and produces a better effect than fresh water. Solutions of soap and of calcium chloride and other salts are also used and it is claimed that these methods are cheaper than sprinkling as ordinarily practiced. We do not believe that water will long survive as a method of laying dust either used by itself or in combination with salt. Even the best salt solutions have to be applied often in hot weather, and this question of frequent application puts them out of the question, especially for rural highway use.

The greatest class of dust layers is made up of oils and tars with more or less paraffine, pitch or asphalt in their composition, according to the source from which they are derived. Some of these are applied hot, some cold, some neat and some in solution, and some in all of the above conditions. We believe that it is to this class of dust preventatives that we must look for the final solution or solutions of the dust and maintenance problem. The oils consist principally of petrolium residuums and can be bought very cheaply at the refineries.

Used in the form of emulsions they are sprinkled on in the same manner as water is sprinkled. In Boston they use 8 to 16 per cent solutions and it is claimed have had excellent success, maintaining the road with the use of one and one-half pints annually at a cost of 2 cents per square yard, considerably cheaper than water sprinkling had previously been.

The Kansas City and more general way is to use the oil neat. The streets are first swept clean and depressions filled with stone until the road surface is smooth and even The oil is then applied at the rate of about one-third gallon per square yard. In cool weather the oil is heated, but in the summer months it is applied unheated. As soon as the oil is applied the sweepings are replaced and additional stone screenings or sand is added to cover the surface and absorb any excess oil. The steam roller then passes over the surface a few times and the street is thrown open to travel immediately. The results in Kansas City have been excellent. A saving of $5,500 was made in 1907 over the cost of water sprinkling the previous year and a large amount could also be credited as saved due to the smaller amount of repairs, ditch and catch basin cleaning, etc. In Kansas City the oil cost only 1.8 cts. per gallon, f. o. b., and the total cost of each application of oil was about 1 cent per square yard. Most of the driveways received two applications each year. I inspected these streets in 1908 and at that time they were in practically perfect condition.

Tars are applied in practically the same way as oils, though I believe are seldom used in solutions. These are usually applied hot as they are too viscous when cold. Coal tar or water gas tar may be used. It is better to drive over the volatile constituents, especially the water before applying tars. Tarvia, A and B, are refined tars and when the cost of these patented preparations is excessive on account of heavy freight costs local tars may be used with good results. It is usual to apply from ½ to 1½ gallons per square yard of surface. One application will usually suffice for a year. In general it is believed that the tar applications are more expensive and more lasting than oil applications. Each method has its advocates and its opponents and out of the conflicting claims it is hoped that some decision will finally be reached as to which is better under each of the various conditions which may arise. The varying results attained both by the use of oils and tars when conditions and the mode of application has been practically the same must be due to variation in the physical and chemical properties of the tars and oils used. Results have varied from almost perfect success to complete failure, and the best authorities seem to agree that tars and oils should be tested before using, and only those having a good percentage of bitumen in their composition used. In Kansas City the best results were had when oil having an asphaltic base was used.

The methods heretofore mentioned simply cover surface treatments after the roads have been completed. While of great assistance in suppressing the dust nuisance they are at best palliatives and not preventtives. Engineers are gradually becoming convinced that the problem is best attached at the time the road is built, and that the preventative material should be incorporated in the road itself at this time. A material to serve thus as a permanent binder must be adhesive, resilient, self healing and not subject to deterioration from frost action.

The bitumens fulfill these conditions and are generally used.

Tar macadam, bituminous macadam and bitulithic are constructed by mixing the wearing coat of the stone with tar of bitumen. In some cases the pavement is hand mixed, i. e., the stone is heated and then coated with the hot binding material by turning with shovels and then spread and rolled. A wearing coat of fine material impregnated with the binder is then spread on this and thoroughly rolled and afterward covered with dry screenings, gravel or sand. So far this method has been successful in producing a pavement that is noiseless, free from dust and mud, and of good wearing qualities. The cost owing to the methods necessary is excessive and precludes the use of this pavement except on much traveled highways.

A second method is to make a matrix of stone and the binding material and spread this upon the thoroughly rolled first course of stone. The second course of stone is then spread and rolled down so that the matrix is pushed up into all the voids, just enough of it being used to compeltely fill the voids. After thorough rolling chips, screenings or sand are spread over the surface and rolled in. Pavement so constructed has also proved satisfactory.

The English are using a method which seems best fitted to solve the problem in an economical way. This method is known as "tar painting." The road is constructed and nearly completed in the same manner as common macadam. The only thing undone is the flushing in of the screenings. After the second course of stone is spread and thoroughly rolled a thin coat of stone chips is applied and rolled in. The tar is then applied at the rate of 1/6 gallon per square yard, this amount being said to be sufficient to fill the voids left after the thorough compacting of the stone. In extra coat of screenings or probably stone chips is then applied absorbing the excess tar of any, and the surface is then rerolled. This method has given great satisfaction and the estimated increase in the cost of macadam is only 20 to 35 cts. per square yard. Every few years the surface of these roads must be swept and repainted, but much less maintenance is required than under the old methods.

Bitulithic and bituminous macadam are laid in practically the same manner but under different conditions as to size of stone and binder used. As they are familiar types of pavement I will only mention them in passing.

Liquid asphalts are used in practically the same manner and have been successful where used. Most of these are patented binders and are somewhat more costly than tars, but seem to give more lasting results It is possible that they may prove the most economical in the long run.

Certain natural rock asphalts are also on the market. These take the place of the ordinary screenings and are applied dry to a depth of from 1 to 2 ins. and are said to produce a surface very near resistant and free from dust.

I have briefly mentioned some of the best known methods of dust prevention but there are many advertised methods which I have not touched upon. The whole world of highway engineers is now engaged with the problem, some think they have solved it for their localities and some still struggle to find the solution. It is believed that in a year or two when some of the methods have had a longer test something definite will be evolved from the mass of data which is being accumulated. Until that time we must work along the lines which appear most promising at the present time. From the reports which have been examined it is believed the following tentative conclusions may be drawn.

Water is the most expensive method. Oil and emulsions of oil give good and cheap results where the cost of oil is not too high. Tar is excellent either as a surface treatment or as a binder incorporated with the road surface. Bitumens are the most permanent incorporated binders and the most satisfactory if the cost is not considered.

The greatest possibility of success lies in the incorporation of the binder substance in the practically completed macadam.

In considering dust preventatives for dirt roads we find much the same conditions as those ruling for stone roads. The first object of oil applications was to lay dust but it was found that the oil not only laid the dust but gave a surface that was hard and rut resistant, and in California, where most of the oiling has been done, oiling is now mainly pursued with the idea of getting a semi-asphaltic surface that is a good substitute for macadam. The oil is sprinkled on the properly shaped roadway at the rate of from 1 to 2 gallons per square yard the first application. The surface is first stirred up to a depth of 2 or 3 ins. and the oil and dirt thoroughly mixed, forming an impervious crust. The second and succeeding years other applications of oil are made at a much decreased rate (almost a quart per square yard). These oil roads have been successful in meeting conditions in the warm and dry climate of California, but they have not been tried extensively in more severe climates and their action under northern conditions is problematical. It would seem to be a fruitful field for experiments in Wisconsin, when funds become available.

The fact that the surface oiled roads have been so successful has induced California to experiment along the lines of deeper impregnation of oil and from these experiments the so-called petrolithic road was evolved. This road is a further development of the oiling idea with the depth of oiled crust of 6 ins. instead of 2 or 3 and with the addition of rolling with a specially constructed roller. This roller rolls from the bottom up and would seem to compact and mix the oil and earth thoroughly.

Unclassified and General Articles

Note: This section is devoted to methods and cost articles on construction work not properly coming under any of the preceding classifications.

Methods and Cost of Constructing Frame Cottages and Service Buildings for the Camaguey, Cuba, Waterworks.

BY HENRY A. YOUNG.

The headworks of the Camaguey waterworks are on the River P[illegible] Grande, 23 kilometers or about 14 miles north of the city. As the river is below the level of the city the water has to be pumped.

Two houses and a latrine were built, consisting of a large house for the pumpman, a smaller one for his assistant and a double latrine in the rear for the use of both houses. The larger house contains six rooms and is built in the form of an L, three rooms across the front and three down the side. The front of the house is 11 meters long by 4.27 meters wide, while the L is about 15.85 meters long by 4.27 meters wide. The height from the sills to the eaves is 3.70 meters. There is a piazza across the front of the house 1.83 meters wide, while a "patio" is enclosed between the two L's of the house, and a picket fence set on a low stone wall. A concrete walk 1.00 meters wide and 12 cm. thick extends around the two house sides of the "patio," a porch roof projecting from the house and covering the concrete walk.

The smaller house contains but three rooms in the form of an L. The front part of the house is 7.0x3.66 meters, while the third room or kitchen is 3.05x3.05 meters. The height to the eaves from the sills is 3.15 meters. There is a piazza across the front of the house 1.83 meters wide. The "patio" in the rear of this house is also surrounded by a low stone wall and a picket fence, and there is no concrete walk or porch roof.

The latrine, which is in the rear of the two houses, contains two compartments. The frame structure is 2.0x1.70 meters and is built in the same style as the two houses. It is 2.44 meters high to the eaves. Each compartment contains a modern sanitary flush tank closet. The building is set over a concrete tank 2.00x1.70 meters and 1.00 meters deep, having walls and floor 15 cm. thick. This tank is supplied with [illegible] pipe [illegible] and discharge [illegible] to [illegible] the septic tank [illegible].

The houses are not set on foundations but on hardwood [illegible] posts 20 cm. (8 ins.) in diameter and from 3 to 4 ft. long, spaced about 2.5 meters [illegible]. The space between the sills and the ground is covered with 1x8-in. pine planks nailed to the [illegible] posts. The house sills are of native hardwood 6x6 ins., sawed to size and are mortised or notched at all joints. The joists are [illegible] spaced.

The balance of the timber is of American pine dressed on four sides. The flooring and siding came direct from the States and was of very fair quality. The studding, planking, etc., came to Camaguey in logs and was sawed and dressed in the local mill.

Pumpmen's Houses at Headworks of Camaguey Water Works

Under the heading of rough framing is included the studding, rafters, floor beams, porch railings, and the 1x3-in. strips spaced 75 cm. c. to c. to support the [illegible]. It includes the entire framework of the buildings. This lumber was dressed on all four sides, because it was intended to leave it exposed in the interior of the dwellings, the studding being left exposed. The [illegible] [illegible] it was intended that at some future time the rooms would be plastered or ceiled [illegible].

The siding is the so-called "Novelty" siding [illegible] and the flooring is standard [illegible] T. & G. flooring. This was also used in the ceiling of porches, which [illegible] are tongued with the flooring, [illegible] at the same place. Partitions are [illegible] on one side only, [illegible] surfaced on both sides as in the rest of the houses. All roof [illegible] and rafters are 2x4 [illegible] spaced 50 cm. or 20 ins.

The doors and windows were a [illegible]. They [illegible] and were made in the local mill. It was expected that

ASSISTANT PUMPMAN HOUSE AT HEADWORKS.

	Days.	Rate.	Amount.	Total.	Unit Cost.
Cutting to Length and Setting Jiqui (Hardwood) Foundation Posts:					
Labor:					
Carpenter	4	$3.25	$13.00		
Carpenter's helper	1½	1.50	2.25		
Laborers	11½	1.10	12.65		
Total labor cutting and setting hardwood foundation posts, 320 ft. B. M.				$ 27.90	$87.19 per M. ft. B. M.
Materials:					
320 ft. B. M. 8-in. diam. jiqui (hardwood) foundation posts		$29.00	9.28		
Chalk, line, etc.			.10		
Total materials, hardwood foundation posts (8-in. diam.), 320 ft. B. M.				9.38	29.31 per M. ft. B. M.
Framing and Placing 6"x6" Hardwood House Sills:					
Labor:					
Carpenter	4	3.25	13.00		
Carpenter	2½	3.00	7.50		
Carpenter	2½	2.00	5.00		
Carpenter's helper	1½	1.50	2.25		
Total labor framing and placing hardwood house sills, 453.67 ft. B. M.				27.75	61.17 per M. ft. B. M.
Materials:					
453.67 ft. B. M. 6x8 in. (squared) hardwood sills		55.00	24.95		
25 lbs. nails (10 lbs. 30d., 15 lbs. 60d.)		4.25	1.06		
Total materials, hardwood house sills, 453.67 ft. B. M.				26.01	57.33 per M. ft. B. M.
Framing and Erecting Floor Beams, Studding, Rafters, 1"x3" Strips for Tile, Porch Railings, Etc.:					
Labor:					
Carpenter	18½	3.25	60.13		
Carpenter	3	3.00	9.00		
Carpenter	11½	2.00	23.00		
Carpenter's helper	3½	1.50	5.25		
Laborers	2	1.10	2.20		
Total labor framing and erecting floorbeams, studding, rafters, etc., 2,807 ft. B. M.				99.58	35.48 per M. ft. B. M.
Materials:					
2,517 ft. B. M. pine lumber (d. 4 s.)		41.50	104.46		
290 ft. B. M. pine lumber (d. 4 s.)		44.00	12.76		
70 lbs. nails (55 lbs. 16d., 15 lbs. 30d.)		4.25	2.98		
Total materials for framework (floor beams, studding, rafters, etc.), 2,807 ft. B. M.				120.20	42.82 per M. ft. B. M.
Placing Siding (Novelty Siding):					
Labor:					
Carpenter	1	3.25	3.25		
Carpenter	9	3.00	27.00		
Carpenter	12	2.00	24.00		
Carpenter's helper	6½	1.50	9.75		
Laborers	4	1.10	4.40		
Total labor placing siding, 1,600 ft B. M.				68.40	42.75 per M. ft. B. M.
Materials:					
83 ft. B. M. Novelty siding (1x8 in)		44.00	3.65		
1,016 ft. B. M. Novelty siding (1x8 in.)		42.00	42.67		
501 ft. B. M. pine lumber (d. 4 s.), (1x8 in. & 1x6 in. & 1x5 in. & 2x6 in.)		44.00	22.04		
60 lbs. nails, 8d		4.25	2.55		
Total materials for siding, 1,600 ft. B. M.				70.91	44.32 per M. ft. B. M.
Laying Floors and Ceiling Portitions:					
Labor:					
Carpenter	1	3.25	3.25		
Carpenter	3½	3.00	10.50		
Carpenter	4	2.00	8.00		
Total labor laying floors and ceiling partitions, 988 ft. B. M.				21.75	22.01 per M. ft. B. M.
Materials:					
988 ft. B. M. 4-in. t. & g. flooring		42.00	41.50		
30 lbs. nails, 8d		4.25	1.28		
Total materials, floors and partitions, 988 ft. B. M.				42.78	43.30 per M. ft. B. M.
Doors and Windows (Including Setting and Casings):					
Labor:					
Carpenter	11	3.25	35.75		
Carpenter	6½	3.00	19.50		
Total labor finishing and erecting doors, windows and casings (156.12 sq. ft. doors and windows)				55.25	0.354 per sq. ft.
Materials:					
156.12 sq. ft. paneled cedar doors and windows (complete)		.35	54.64		
201 ft. B. M. pine lumber (d. 4 s.) casings		44.00	8.84		
Hardware (locks, chain catches, foot bolts, hinges, screws, catches, etc.)			5.60		
170 lbs. ½-in. iron rod for window gratings		3.70	6.29		
5 panes of window glass (to replace breakage)		.20	1.00		
5 sheets sandpaper		.01	.05		
3 lbs. putty		.15	.45		
5 lbs. nails, 8d		4.25	.21		
5 lbs. assorted nails		.07	.35		
½ package small wire nails			.05		
Total materials for doors, windows and casings, (156.12 sq. ft. of doors and windows)				77.48	0.496 per sq. ft.
French Tile Roof:					
Labor:					
Mason	3½	2.75	9.63		
Carpenter's helper	7½	1.50	11.25		
Laborers	12	1.10	13.20		
Total labor laying French tile roof, 728 sq. ft.				34.08	0.0468 per sq. ft.
(Total labor laying French tile roof, per M., flat tile, $33.35.)					
Materials:					
1,022 French tile		78.43	80.16		
38 ridge tile		94.72	3.60		
Charge for unloading above tile at station			1.85		
5 lbs. fine wire		.08	.40		
2½ lbs. staples		.32	.80		
2 meters galv. iron wire mesh (reinforcing mortar gutters)		.60	1.20		
2 sacks lime		.50	1.00		
¼ cu. m. sand		3.00	.75		
½ barrel cement		3.45	1.73		
Total materials for French tile roof, 728 sq. ft.				91.49	0.1257 per sq. ft.
(Total materials for French tile roof, per M., flat tiles, $89.52.)					

they would be turned out in good shape ready for use, but the workmanship was exceedingly poor and much labor was wasted in truing them up and sandpapering them to a reasonable degree of smoothness. It would have been much cheaper if the lumber had been purchased and the doors and windows made by the carpenters on the ground. There are 10 doors and 8 windows in the larger house. The doors are in two leaves and all but one are 2.70 meters high by 1.20 meters wide. The front door is 3.00 meters high by 1.50 meters wide. The windows are also in two leaves, swinging inwards, the total opening being 1.20x2.00 meters. Each leaf has one pane of glass 14x16 ins., with a swinging shutter covering the glazed opening. The window openings are protected by barred gratings. The doors are provided with American mortise locks, and both doors and windows are supplied with foot bolts and also with chain catches for the tops. In the small house there are four doors and four windows. The doors consist of only one leaf and are 1.06x2.10 meters. The windows are of the same style as in the other house, but are only 1.00x1.40 meters. The glasses are 8x12 ins.

The roofs are of the ordinary peaked style on a slope of 1½ to 1. On a house previously built fibro-cement shingles had been used, but they never gave satisfaction. They cost in labor $0.00679 per sq. ft., and in materials $0.102 per sq. ft., or a total of $0.10879 per sq. ft. They cracked easily when anything fell on them or it was necessary to go on the roof to make repairs and with the 3-in. lap recommended by the makers they did not keep out the driving tropical rains and the roof leaked like a sieve. This was due to the fact that the clips furnished with the shingles permitted too much motion when the wind got under the edges. If a 6-in. lap had been used the expense would have been about equivalent to the French tile. Undoubtedly the semi-circular or Spanish tile makes the best roof for a tropical climate, but as this is so heavy, French tile is the best material for wooden buildings of this class. It is easily laid and makes a light roof. In shipping the tile on the railroad from Havana to Camagüey 5 per cent were found broken more or less. However most of this was usable in the valleys of the roofs where tile had to be cut anyway and in completing the top row of tiles under the ridge pieces. Only 0.7 per cent was a total loss on the railroad. In hauling the 14 miles over rough roads from Camagüey to the headworks 4 per cent more of the tiles were broken on the edges, though most of them were usable. For freight shipment and a haul like the one here considered probably 5 per cent of total loss of tile would more than cover the actual wastage. The flat tile are 40x25 cm. outside and lay 35x20 cm. neat. They weigh 5¼ lbs. apiece. The ridge tile are 40 cm. long and weigh 4¾ lbs. each. Fifteen tiles are required per square meter. Allowing

Painting—First Coat

Labor					
Painter	9	2.00	18.00		
Laborers	1½	1.10	1.65		
Total labor painting 237 sq. yds				19.65	0.0829 per sq. yd
Materials					
8½ gals. mixed paint		1.25	10.63		
¼ gal. linseed oil		1.25	.31		
2 quarts linseed oil		.30	.60		
5 lbs. putty		.15	.75		
½ bottle varnish			.12		
5 sheets sandpaper		.01	.05		
1 paint brush		1.25	1.25		
Total materials painting 237 sq. yds				13.71	0.0578 per sq. yd

Painting 2d Coat

Labor					
Painter	7½	2.00	15.00		
Total labor painting 237 sq. yds				15.00	0.0633 per sq. yd
Materials					
6½ gals. mixed paints		1.25	8.13		
¼ gal. linseed oil		1.25	.31		
1 paint brush		.55	.55		
Total materials painting 237 sq. yds				8.99	0.0379 per sq. yd

Painting 3d Coat

Labor					
Painter	5½	2.00	11.00		
Total labor for painting 237 sq. yds				11.00	0.0464 per sq. yd
Materials					
2½ gals. mixed paint		1.25	3.13		
½ gal. linseed oil		1.25	.63		
½ lb. lampblack (darkening trimmings)		.18	.09		
1 paint brush		.50	.50		
Total materials painting 237 sq. yds				4.35	0.0184 per sq. yd

Hauling Materials (Camaguey to Headworks 15 Miles)

50 lbs. of oats for food	2.98	1.49		
Driver (with department team hauling incidentals) 6 days	1.10	6.60		
Hardwood lumber 2.01 tons	6.00	12.06		
Pine lumber, doors, windows, cement, sand, stone, etc. 12.8 tons	6.00	76.80		
Total cost of hauling 16.17 tons (2,000 lbs.)			96.95	6.00 per ton

Fogones (Brick Fire Places)

Labor					
Mason	2¾	2.75	7.56		
Laborers	2¼	1.10	2.48		
Total labor brick fireplace, 375 brick				10.04	26.77 per M
Materials					
½ cu. m. sand		3.00	1.50		
½ bbl. cement		3.45	1.73		
2 sacks lime		.50	1.00		
375 brick (native 12¼x6¾x1½ in.)		12.00	4.50		
22¼ lbs. cast iron grates		.05	1.11		
1 galv. iron hood smokestack flashing, etc.		10.00	10.00		
Total materials for brick fireplace, 375 brick				19.84	52.91 per M

General Items—Miscellaneous Expenses

Labor					
Carpenter	3	3.25	9.75		
Carpenter	1	3.00	3.00		
Carpenter	1½	2.00	3.00		
Carpenter's helper	1	1.50	1.50		
Mason	1	2.75	2.75		
Painter	1	2.00	2.00		
Laborers	24½	1.10	26.95		
Total labor, general items, distributed for total lumber used in house, except doors & windows, 6,619 ft. B. M.				48.95	7.40 per M ft. B. M.
Materials					
Galvanized iron roof gutters and supports, 4.5 meters		.70	3.15		
19 ft. B. M. cedar for gate		40.00	.76		
60 ft. B. M. pine lumber (d. 1 s.)		41.50	2.49		
170 ft. B. M. hardwood for house steps and fence posts		55.00	9.35		
½ cu. m. of sand		3.00	1.50		
1 gate latch and 4 hammock hooks			.85		
2 sacks lime		.50	1.00		
½ gal. mixed paint		1.25	.63		
Total materials, general items, distributed for total lumber used in house except doors and windows, 6,619 ft. B. M.				19.73	2.98 per M ft. B. M.
Total cost of house, 6,619 ft. B. M. lumber used (not including doors and windows)				$1,041.17	$157.30 per M ft. B. M.

The following summary shows the unit cost of each of the above items reduced to the basis of thousand feet of lumber used in the house and to the cubical contents below the eaves. 6,619 ft. B. M. of lumber were used in all and the cubical contents below the eaves was found to be 5,065 cu. ft.

Summary

	Amount	Cost Per M Ft. B. M.	Cost Per Cubic Ft. Contents
Cutting and setting hard foundation posts—			
Labor	$27.90	$4.21	$0.0055
Materials	9.58	1.44	[illegible]
Framing and placing 6x6-in. hardwood house sills—			
Labor	[illegible]	1.12	[illegible]
Materials	26.01	3.93	[illegible]
Framing and erecting floorbeams, studding, rafters, etc.—			
Labor	99.58	15.04	.0196
Materials	120.20	18.16	[illegible]
Placing Novelty siding—			
Labor	68.41	10.34	[illegible]
Materials	70.91	10.71	.0140
Laying floor and ceiling partitions—			
Labor	21.75	3.29	[illegible]
Materials	42.78	6.46	[illegible]
Setting doors and windows (including castings)—			
Labor	[illegible]	[illegible]	[illegible]
Materials	77.48	11.71	[illegible]

[illegible] weight [illegible] of tiles actually used came to 15.11 per square meter, or 1.404 per sq. ft. The flat tile were laid on 1x1-in. strips, a wire being passed through a lug on each tile and stapled to the strips at intervals. The ridge tiles were laid in lime mortar. The valleys in the roofs were made of cement mortar reinforced with wire mesh. Over this, as being less liable to crack, was spread a ½-in. coat of lime mortar. Up to the present these valleys have not leaked, but it is expected that they will. Any walking on the tiles lining the edges of the valley cracks the mortar. Lining the valley with tin underneath the mortar would have ensured tightness.

The painting was rather expensive. It was well done, the paint having been brushed in thoroughly, but the painter, who was an American, was undoubtedly slow.

The hauling, which was done during the rainy season when the roads were very bad, cost $8 a ton and was done by contract. The haul, as before mentioned, was over a distance of 23 kilometers, or about 14 miles. If the hauling had been done after Nov. 15, or during the dry season, the cost would have been only $4.50 per ton of 2,000 lbs.

Under the miscellaneous expenses are included all extras and general work. This item includes the cost of a cook, building a thatched rancho for kitchen, tables and other general camp expenses. The fences surrounding the two patios are of the wooden picket variety, built over a low stone wall laid in lime mortar. The patios were leveled up with gravel. The posts for the fences are of hardwood and the gates are of cedar. The "fogones," or native fireplaces are 1.80x0.60x0.90 meters. They each contains three cast iron charcoal pots. Over each "fogon" is a galvanized iron hood with pipe extending through the roof provided with flashings and hood. All steps for both houses are of mahogany or other hardwood. The portico roof on the two sides of the patio of the large house is supplied with a 6-in. galvanized iron gutter with 4-in. downspouts at each end. All other unprotected doors are supplied with short gutters so as to throw the drip each side of the doorway.

Work was begun on Sept. 9, 1908, and lasted till Jan. 25, 1909. Some trouble was experienced from rains, which were heavy during most of this time. The boss carpenter was an American. He was in charge of the camp and was very efficient. Throughout most of the work he had another American carpenter and throughout the first two and a half months he also had two native carpenters. Every endeavor was made to get substantial, first class work, and the cost data are reasonable for the class of work obtained, for an isolated job in this locality. If the hauling had been less or over better roads, if the general camp expense had not been charged in, and if a poorer class of workmanship had been permitted, the total cost per M

French tile roof—			
Labor	34.08	5.15	.0094
Materials	91.49	13.82	.0254
Painting, 3 coats—			
Labor	45.65	6.90	.0127
Materials	27.05	4.09	.0075
Hauling materials	96.95	14.65	.0269
Miscellaneous expenses—			
Labor	48.95	7.40	.0136
Materials	19.73	2.98	.0055
Grand total	$1,041.17	$157.30	$0.2888

PUMPMAN'S HOUSE AT HEADWORKS.

	Rate.	Amount.	Total.	Unit cost.
Cutting to Length and Setting Jiqui (Hardwood) Foundation Posts:				
Labor:				
Carpenter, 3 days	$3.25	$ 9.75		
Carpenter, 1 day	3.00	3 00		
Carpenter, 2 days	2.00	4.00		
Carpenter's helper, 3 days	1.50	4.50		
Laborers, 13 days	1.10	14.30		
Total labor cutting and setting hardwood foundation posts (8" diam.) 740 FBM			$35.55	48.04 per M. ft B. M.
Materials:				
740 ft. B. M. of 8 ins. diam. jiquí (hardwood) foundation posts	$29.00	$21.46		
Chalk, line, etc		.20		
Total materials hardwood foundation posts 740 ft. B. M			$21.66	29.27 per M. ft. B. M.
Framing and Placing 6 x6 Hardwood House Sills:				
Labor:				
Carpenter, 3 days	$3.25	$9.75		
Carpenter, 2½ days	3.00	7.50		
Carpenter, 2½ days	2.00	5.00		
Carpenter's helper, 2½ days	1.50	3.75		
Total labor framing and placing hardwood house sills, 800 ft. B. M.			$26.00	32.50 per M ft. B. M.
Materials:				
800 ft. B. M. 6x6 in. (squared) hardwood sills	$55.00	$44.00		
40 lbs. nails (15 30d) (25 60d)	4.25	1.70		
Total materials hardwood house sills, 800 ft. B. M.			$45.70	57.13 per M. ft. B. M.
(Nails used at rate of 18¾ lbs. per M. ft. for 30d.)				
(Nails used at rate of 31¾ lbs. per M. ft. for 60d.)				
Framing and, Erecting Floor Beams, Studding, Rafters, 1x3 in. Strips for Tile, Porch Railing, Etc.:				
Labor:				
Carpenter, 21 days	$3.25	$68.25		
Carpenter, 25½ days	3.00	76.50		
Carpenter, 15 days	2.00	30.00		
Carpenter's helper, 3 days	1.50	4.50		
Laborers, 7 days	1.10	7.70		
Total labor framing and erecting floor beams, studding, rafters, etc., 7363 FBM			$186.95	25.39 per M. ft. B. M.
Materials:				
6,012 ft. B. M. pine lumber (d. y. s.)	$41.50	$249.50		
1,351 ft. B. M. pine lumber (d. y. s.)	44.00	59.44		
140 lbs. nails (105 lbs. 16d), (35 lbs. 30d)	4.25	5.95		
Total materials for framework (floor beams, studding, rafters, etc.), 7.363 ft. B. M.			$314.89	42.77 per M. ft B. M.
(Nails used at rate of 14¼ lbs. per M. ft. B. M. for 16d).				
(Nails used at rate of 4¾ lbs. per M. ft. B. M. for 30d).				
Placing Siding—(Novelty Siding):				
Labor:				
Carpenter, 5 days	$3.25	$16.25		
Carpenter, 9 days	3.00	27.00		
Carpenter, 9½ days	2.00	19.00		
Laborers, 2 days	1.10	2.20		
Total labor placing siding, 3.817 ft. B. M.			$64.45	16.88 per M. ft. B. M.
Materials:				
2,559 ft B. M. novelty siding (1"x8")	$42.00	$107.48		
209 ft. B. M. novelty siding (1"x8")	44.00	9.20		
1,049 ft. B. M. pine lumber (d. y. s.) 1"x8", 1"x5", 1"x4", 2"x6"	44.00	46.16		
160 lbs. nails, 8d	4.25	6.80		
Total material for siding, 3.817 ft. B. M.			$169.64	44.44 per M. ft. B. M.
(Nails used at rate of 41.9 lbs. per M. ft. 8d).				
Laying Floors and Ceiling Partitions:				
Labor:				
Carpenter, 6 days	$3.25	$19.50		
Carpenter, 6 days	3.00	18.00		
Carpenter, 5½ days	2.00	11.00		
Laborers, 2 days	1.10	2.20		
Total labor laying floors and ceiling partitions, 2.997 ft. B. M.			$50.70	$16.92 per M. ft. B. M.
Materials:				
2,997 ft. B. M. 4-in. t. and g. flooring	$42.00	$125.87		
80 lbs. nails, 8d	4.25	3.40		
Total materials floors and partitions, 2.997 ft. B. M.			$129.27	$43.13 per M. ft. B. M
(Nails used at rate of 26.7 lbs. per M. ft., 8d).				
Doors and Windows (Including Setting and Casings):				
Labor:				
Carpenter, 21 days	$3.25	$68.25		
Carpenter, 10 days	3.00	30.00		
Carpenter, 5 days	2.00	10.00		
Laborers, 1 day	1.10	1.10		
Total labor finishing and erecting doors, windows and casings (567.67 sq. ft. of doors and windows)			$109.35	0.193 per sq. ft.
Materials:				
567.67 sq. ft. paneled cedar doors and windows (complete)	$0.35	$198.68		
519 ft. B. M. pine lumber (d. y. s.) casings	44.00	22.84		
Hardware (locks, chain catches, foot bolts, hinges, screws, catches, etc.)	....	29.61		
395 lbs. ½" iron rods for window gratings	3.70	14.62		
2 panes window glass 20⅛"x17⅛" (to replace breakage)	0.60	1.20		
15 sheets sand paper	0.01	.15		
8 lbs. putty	0.15	1.20		
10 lbs. nails, 8d	4.25	.43		
15 lbs. assorted nails	0.07	1.05		
½ package small wire nails	....	.05		
Total materials for doors, windows and casings (567.67 sq. ft. of doors and windows)			$269.83	0.475 per sq. ft.

ft., B. M., might have been reduced about $20; but on the whole the costs can be taken as fair for the conditions.

It will be noticed that the costs for the small house are all higher than those on the large house. This can be accounted for in that it is always more expensive to do a small piece of work than a larger; and more especially by the fact that this was the first of the two houses built. By the time the carpenters got to the large house they knew just what to do.

The prices given are in U. S. currency and the costs cover all necessary work except general supervision and the time spent in purchasing materials. The work was done by the department on the day labor basis.

Tractive Resistances Using Steel Tired and Pneumatic Tired Vehicles.

Data on the resistance to traction at low speed on roads are abundant but very conflicting. Corresponding data at high speeds are exceedingly meager, although of growing importance, especially to the manufacturers and users of motor cars.

Some comparatively recent dynamometer tests are recorded in the 1907 edition of Aitken's "Road Making and Maintenance," but not in from that admits of ready comparison with other tests. We have, therefore, changed the form of the records so as to show the tractional resistance in pounds per ton of 2,000 lbs., for steel tired and pneumatic tired vehicles.

The dynamometer was one made for the "British Association Committee," and is fully illustrated in Aitken's book. In testing the tractional resistance of a wagon wheel, the wheel is mounted in a frame that is trailed behind an automobile. This frame is loaded with iron to any desired weight. The recording apparatus is in the automobile, and consists of a combined recording pressure-gage and tachometer, so that the resistance to traction and the speed of the vehicle are recorded on paper.

An iron tired wheel, 40 ins. in diameter, 3 in. tire, running on a stone block pavement, showed the following resistances when running at a speed of 10 miles per hour. The wheel was provided with plate springs:

Load on wheel, lbs.	Resistance in lbs. per ton of 2,000 lbs.
392	122
672	104
952	95

This shows a very marked decrease in tractive resistance per ton as the wheel load increases.

To show the effect of speed in increasing the tractive resistance, the following table will serve. Using the same wheel

French Tile Roof

Labor				
Carpenter, ½ day	$3.00	$1.50		
Mason, 2 days	2.75	5.50		
Mechanic, 7 days	2.00	14.00		
Laborers, 25½ days	1.10	28.05		
Total labor laying French tile roof 2,562 sq ft			$49.05	0.0191 per sq ft
(Total labor laying French tile roof per M tiles = 13.68)				
Materials				
3,585 French tile	$78.43	$281.19		
82 ridge tile	91.72	7.77		
Charge for unloading above tile at station		6.15		
15 lbs tile wire	0.08	1.20		
5 lbs staples	0.25	1.25		
6 meters galv. iron wire mesh (reinforcing mortar gutter)	0.60	3.60		
1¼ lbs rope		.25		
3 sacks lime	0.50	1.50		
½ cu meter sand	3.00	1.50		
1 bbl cement	3.45	3.45		
Total materials for French tile roof 2,562 sq ft			$308.82	0.1205 per sq ft
(Total materials per M flat tiles = $85.80)				

Painting 1st Coat

Labor				
Painter, 19½ days	$2.00	$39.00		
Total labor painting 645 sq yds			$39.00	0.0605 per sq yd
Materials				
15 gals mixed paint	$1.25	$18.75		
3½ gals linseed oil	1.25	4.38		
10 lbs putty	0.15	1.50		
½ bottle varnish		.13		
10 sheets sand paper	0.01	.10		
1 paint brush	1.25	1.25		
Total materials painting 645 sq yds			$26.11	0.0405 per sq yd

Painting 2d Coat

Labor				
Painter, 20¾ days	$2.00	$41.50		
Total labor painting 645 sq yds	....	...	$41.50	0.0643 per sq yd
Materials				
10 gals mixed paint	$1.25	$12.50		
3 gals linseed oil	1.25	3.75		
1 paint brush	1.25	1.25		
Total materials painting 645 sq yds			$17.50	0.0271 per sq yd

Painting, 3d Coat

Labor				
Painter, 10½ days	$3.25	$34.13		
Painter, 3 days	2.00	6.00		
Total labor painting 645 sq yds	....	....	$40.13	0.0622 per sq yd
Materials				
5 gals. mixed paint	$1.25	$6.25		
1 gal linseed oil	1.25	1.25		
1½ lbs lamp black (darkening trimmings)	0.18	.27		
1 paint brush	1.25	1.25		
Total materials painting 645 sq. yds		...	$9.02	0.0140 per sq yd

Hauling Materials (Camaguey to Headworks, 15 Miles):

150 lbs oats for feed	$2.99	$4.49		
Driver (with department team hauling incidentals), 18 days	1.10	19.80		
Hardwood lumber, 3.446 tons	6.00	20.68		
Pine lumber, doors, windows, cement, sand, stone, etc., 35.5 tons	6.00	213.00		
Total cost hauling 42.946 tons (2,000 lbs.)			$257.97	$6.01 per ton

"Fogones" (Brick Fireplaces)

Labor				
Mason, 2¾ days	$2.75	$7.56		
Laborer, 2¼ days	1.10	2.48		
Total labor brick fireplace (12¼"x6¾"x1½")		....	$10.04	$26.77 per M
Materials				
½ cu meter sand	$3.00	$1.50		
½ bbl cement	3.45	1.73		
2 sacks lime	0.50	1.00		
375 brick (native 12"x6¾"x1½")	12.00	4.50		
22¼ lbs cast iron grates	0.05	1.11		
1 galv. iron hood, smoke stack, flashing, etc.	10.00	10.00		
Total materials brick fireplace 375 brick		..	$19.84	$52.91 per M

General Items—Miscellaneous Expenses:

Labor:				
Carpenter, 9 days	$3.25	$29.25		
Carpenter, 2 days	3.00	6.00		
Carpenter's helper, 2 days	1.50	3.00		
Mason, 3½ days	2.75	9.63		
Painter, 2 days	2.00	4.00		
Laborers, 77 days	1.10	84.70		
Total labor general items. Distributed for total lumber used in house, except doors and windows, 16,712 ft. B. M.			$136.58	$8.17 per M ft. B. M.
Materials				
6 in. galv. iron roof gutters and supports, 26.94 meters	$0.70	$18.86		
19 ft. B. M. cedar for gates	40.00	.76		
150 ft. B. M. pine lumber (d 4 s)	41.50	6.23		
607 ft. B. M. hardwood for house steps and fence posts	[illegible]	16.89		
10½ bbls cement	3.45	36.23		
2.15 cu. meters sand	3.00	6.45		
4.32 cu. meters broken stone	2.60	11.23		
1 gate latch	0.50	0.50		
4 sacks lime	0.50	2.00		
1 gal. mixed paint	1.25	1.25		
Total materials general items. Distributed for total lumber used in house, except doors and windows, 16,712 ft. B. M.			$100.40	$6.01 per M ft. B. M.
Total cost of house, 16,712 ft. B. M. lumber used (not including doors and windows)			$2,479.96	$148.39 per M ft. B. M.

The following summary shows the unit cost of each of the above items reduced to the basis of thousand feet of lumber used in the house and to the cubical contents below the eaves; 16,712 ft. B. M. of lumber were used in all and the total cubical contents below the eaves was found to be 13,616 cu. ft.

as before, loaded with 672 lbs., the results were as follows:

Speed Miles per hour	Resistance in lbs per ton of 2,000 lbs
5½	67
7	81
9	98
11	111
12½	119

This shows a striking increase in the tractive resistance with the increased speed. The increased resistance was even more marked when the wheel was loaded with 952 lbs., for at 12 miles per hour the resistance was 22 per cent greater than at 10 miles per hour.

Experiments were made with a pneumatic tired automobile wheel, 21 ins. diam., 2¾ in. tire, steel spokes, provided with springs. On macadam, traveling at 10 miles per hour, the tractive resistance under different wheel loads was as follows:

Load on wheel, lbs.	Resistance in lbs per ton of 2,000 lbs.
315	127
427	120
539	120
651	120

From this it will be noted that increasing the load had little effect upon the tractive resistance per ton.

Changing the speed of travel had a very noticeable effect, although by no means as pronounced as in the case of the iron tired wheel. At 15 miles per hour the tractive resistance was about 6 per cent greater than at 10 miles per hour. Within the range of the experiments on this wheel—6 to 15 miles—the curve of increased resistance was almost a straight line. Additional tests were made with a larger automobile wheel having wooden spokes. The first tests were made with a 34-in. pneumatic tire having a 4½ in. cross section, and the load on the wheel was 896 lbs. The wheel was provided with springs. Running on hard frozen macadam the resistances were as follows:

Speed miles per hour	Resistance in lbs per ton of 2,000 lbs
14	80
20	87
30	95

It is an interesting fact that this same wheel running on a stone block pavement showed a tractive resistance about 3 lbs. less per ton at all velocities.

An additional series of tests was made with the same wheel using a 34-in. tire having a section 3½ ins. diam. instead of 4½

Summary.

		Cost per	
	Amount.	M. ft. B. M.	Cubic ft. contents.
Cutting and setting jiquí foundation posts—			
Labor	$ 35.55	$ 2.13	0.0026
Materials	21.66	1.30	0.0016
Framing and placing 6x6 in. hardwood house sills—			
Labor	26.00	1.55	0.0019
Materials	45.70	2.73	0.0034
Framing and erecting floor beams, studdings, rafters, etc.—			
Labor	186.95	11.19	0.0137
Materials	314.89	18.84	0.0231
Placing novelty siding—			
Labor	64.45	3.86	0.0047
Materials	169.64	10.15	0.0125
Laying floor and ceiling partitions—			
Labor	50.70	3.03	0.0037
Materials	129.27	7.73	0.0095
Setting doors and windows (including casings)—			
Labor	109.35	6.54	0.0080
Materials	269.83	16.15	0.0198
French tile roof—			
Labor	49.05	2.93	0.0036
Materials	308.83	18.48	0.0227
Painting, three coats—			
Labor	120.63	7.22	0.0089
Materials	52.63	3.15	0.0039
Hauling materials	257.97	15.44	0.0189
Fogón (fireplace)	29.88	1.79	0.0022
Miscellaneous expenses—			
Labor	136.58	8.17	0.0100
Materials	100.40	6.01	0.0074
Grand total	$2,479.96	$148.39	0.1821

DOUBLE CLOSET LETRINA AT HEADWORKS.

Labor:	Rate.	Amount.	Total.	Unit cost.
Carpenter, 9½ days	$3.25	$30.88		
Carpenter, 5 days	3.00	15.00		
Mason, 2 days	2.75	5.50		
Painter, 2¼ days	2.00	4.50		
Laborers, 22½ days	1.10	24.75		
Total labor for letrina			$80.63	
Materials:				
650 ft. B. M. pine lumber (d. 4 s.)	$41.50	$26.98		
199 ft. B. M. pine lumber (d. 4 s.)	44.00	8.76		
400 ft. B. M. novelty siding and flooring	42.00	16.80		
15 ft. B. M. novelty siding	44.00	.66		
14 ft. B. M. cedar for ventilating windows	40.00	.56		
90 ft. B. M. 6"x6" hardwood sills	55.00	4.95		
Hauling materials	8.44	8.44		
7 bbls. Portland cement	3.45	24.15		
1 cu. meter sand	3.00	3.00		
2.7 cu. meters broken stone	2.60	7.02		
1 sack lime	0.50	.50		
2 flush tank water closets	20.00	40.00		
4 lengths soil pipe and tee	....	9.35		
130 French tile	78.43	10.20		
9 ridge tile	94.72	.85		
1 paint brush	0.60	.60		
2 gals. mixed paint	1.25	2.50		
10 lbs. nails (5 lbs. 8d), (5 lbs. 16d)	4.25	.43		
Hardware	....	1.56		
Total materials for letrina			$167.31	
Total cost of double closet letrina			$247.94	

---

ins. The load was the same (896 lbs.) and the resistances were as follows:

Speed miles per hour.	Resistance in lbs. per ton of 2,000 lbs.
14	66
20	73
30	82
35	84

It will be noticed that this tire of smaller cross-section shows a very marked decreased tractive resistance, which is ascribed to the greater elasticity of the smaller tire, whose thickness was considerably less than that of the larger tire.

It will also be noticed that the 34-in. tire showed very much less resistance than the 24-in. tire, which was to be expected.

One thing that is very striking in all these tests is the high tractive resistance. Of course the tests were all made at much greater speeds than occur in hauling heavy loads with horses on traction engines, the wheel loads are not as great as usually occur in hauling, and the size of the wheels was smaller. All these factors tend to cause decided variations in tractive resistance.

The marked effect of wheel loads upon tractive resistance was painted out first, we believe, by A. M. Wellington in his "Economic Theory of Railway Location," where many tests on freight cars are given.

LETTERS TO THE EDITORS.

Exception Taken to Our Review of "Asphalt."

Sirs: My attention has been called to your review on "Asphalt" and I wish to take exception to the idea conveyed by you that the book contains manufacturers specifications, except in a casual way, when reference has been made to material in which asphalt is used.

I wish to point out that this book is for technical readers and that information is given in regard to asphalt from widely varied sources not hitherto contained in any one book published. However, I would say, that I have received some very flattering remarks from engineers of a high standing, giving their appreciation of the information gathered together in this book.

Yours very truly,
T. Hugh Boorman.

New York, March 13, 1909.

Catalogs Worth Having.

Engineers and contractors should have on file the latest catalogs of machines, tools and supplies that they use. In sending for catalogs reviewed or advertised in this paper, you will confer a favor on us if you will write direct to the advertisers and state that you saw the catalog mentioned in Engineering-Contracting. If you are in the market for tools, machinery or supplies, tell us and we will notify promptly the leading manufacturers.

No. 1176. **Electric Car Equipment and Supplies.**—Electric Service Supplies Co., Philadelphia, Pa.

A 654-page book, cloth bound, called Catalog No. 4, Volume II. Printed on a heavy finished paper with good illustrations. Illustrates and describes all kinds of electric car equipment, conductors' and motormen's supplies, station requisites, electric lamps and sockets, switches, signs, electric heaters, fire extinguishers, car heating stoves, lightning arresters, switches and circuit breakers, fuses, rheostats, wire, gears and pinions, gear cases, axle and armature bearings, babbiting devices, commutators, carbon brushes, brush holders, insulating varnishes, mica, insulating tape, rubber mats, corn and rattan brooms, telephones, testing instruments, car jacks, car replacers, chain blocks, soldering furnaces and tools, pliers, wrenches, vises, files, hammers, drills and other tools. Weights and prices are given.

No. 1177. **Curtis Steam Turbine Generator.**—General Electric Co., Schenectady, N. Y.

This is a handsome pamphlet of 53 pages, devoted to Curtis steam turbine generators. The pamphlet is quite elaborate, so far as details of construction are concerned, containing interior views and cross-sections of various parts of turbine and generator. It describes large and small turbines of vertical and horizontal types, and contains illustrations of numerous representative Curtis turbine installations. The bulletin will be found to contain much of interest to the central station manager.

No. 1178. **Computing Machines.**—Oscar Müller Co., 32 Broadway, New York.

A 16-page catalog, telling of the "Unitas" computing or reckoning machine. The first part of the catalog is devoted to a condensed history of computing machines, and the second part to a description of the "Unitas."

No. 1179. **Plows.**—Parlin & Orendorff Co., Canton, Ill.

This is a very handsome little catalog of 48 pages, telling the history of the company that manufactures the "P. & O." plows, and describing the various departments of the plow factory and the method of making plows.

No 1180. **Road Machinery.**—The Acme Road Machinery Co., Frankfort, N. Y.

This is a 118-page catalog, illustrating and describing the various road building and maintenance tools and implements manufactured and sold by this company, consisting of stone crushers, elevators, bins, screens, road scrapers, gravel excavators, dump cars, road machines, dump wagons, dump carts, stone spreading wagons, plows, wheelbarrows, rollers traction engines, elevating graders, stationary engines, street cleaning apparatus, rock drills, hoisting engines, derricks and scrapers.

No. 1181. **Dump Wagons.**—Glen Wagon Co., Seneca Falls, N. Y.

A catalog devoted to the various kinds of dump wagons manufactured by this company. This company makes dump wagons on the patents of William Atkins, who is claimed to be the pioneer in the dump wagon business. They make drop bottom dump wagons for hauling all kinds of materials, and also make a stone spreading wagon.

No. 1182. **Dump Wagon.**—The Kramer Wagon Co., Oil City, Pa.

A pamphlet illustrating and describing the Oil City dump wagon. A wagon combining, according to the manufacturers' claim, every good feature of the best dump wagons. A photograph is given of a 1½-cu. yd. Oil City wagon, loaded with 5 cu. yds. of sand, a total load of 13,960 lbs., which did not injure the wagon.

No. 1183. **Box Centers for Concrete Culverts.**—Blaw Collapsible Steel Centering Co., Pittsburg, Pa.

An 8-page bulletin showing forms of collapsible steel centering for box culvert work, with a brief description and some comments on the advantages of steel centers.

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The Claim of the "Outlook" That the Head of a Board of Water Supply Should Not Be an Engineer.

A bill has been introduced into the New York state legislature by Lindon Bates, Jr., providing for a reorganization of the boards and commissions that control the water supply of New York City. One of the wisest provisions of this bill reads as follows:

"The mayor of the city of New York shall appoint three persons who shall be commissioners for the purposes hereinafter specified. One of such commissioners shall be designated as president and shall be an engineer who has been in responsible charge of large construction work."

The "Outlook" views with alarm any change in existing bodies engaged in administering the problems of water supply, unnecessarily numerous as those bodies now are, to say the least, and inefficient as some of them are, to say less than the worst. The "Outlook" says:

"It [the bill] furthermore introduces an element of great danger in the provision that the head of the Board must be an engineer. The soundest principles of government administration are violated by the provisions. When a municipality or a state or a nation which is democratic in its government undertakes a great work of construction its responsibilities should not be divided with any other power; the administration of the work should be intrusted to a commission most carefully selected and then given the power and held completely responsible, and the function of that commission should be administrative, not technical, for the moment it assumes to overrule on technical grounds the engineers to whom it looks for expert work, that moment it begins to disintegrate its own organization."

This is humorous though written with all gravity. The "Outlook" apparently is not aware that the present head of the New York City board of water supply, John A. Bensel, M. Am. Soc. C. E., is an engineer. No sounds of the board's disintegration have yet reached our ears in spite of this ominous fact.

The "Outlook" evidently has some very hazy ideas about what constitutes the work of administering a water supply project. Possibly it has in mind a board of lawyers or of doctors or of merchants or a mixture of all three, whose function it is to select a number of engineers, sign their names to listen to reports and otherwise [illegible] themselves in a highly dignified and "executive" manner. [illegible]

The [illegible]

Mr. Bates' bill provides that one of the other four commissioners shall also be a civil engineer, and that he shall serve as consulting engineer. Of the remaining three commissioners, two are appointed by the board of estimate and apportionment, and one of these two must be a certified public accountant. The fifth commissioner is to be appointed by the governor.

The salary of the president of the board is to be $20,000, and each of the other four members is to receive $12,000.

The Permanent Organization of the American Society of Engineering Contractors.

The permanent organization of the American Society of Engineering Contractors was effected at a meeting held at the United Engineering Societies Building, in New York, on April 14 and 15.

At 1 p. m. on April 14, the meeting was called to order by Mr. H. P. Gillette, who has been acting as secretary pro tem. and has obtained more than 1,500 applications for membership. Mr. Gillette was made temporary chairman and Mr. Daniel J. Hauer temporary secretary.

The chairman appointed a committee consisting of Prof. Alexander Haring of the University of New York and Messrs. W. D. Lockwood and Daniel J. Hauer to draft a constitution for the society, and a second committee to nominate officers and directors for the first year. The society then adjourned to meet at 1 p. m. on April 15.

At the meeting on April 15 the constitution was adopted, and officers to serve until January, 1910, were elected. It was the sentiment of the meeting that the constitution be submitted to the membership of the society for suggestions and improvement as soon as the Board of Directors can arrange to have this done.

The name adopted was the American Society of Engineering Contractors. The constitution states the object of the society as follows:

"Its object shall be [illegible]"

The means for accomplishing these objects shall be the presentation and discussion of papers, the publication of such papers, [illegible]

The constitution provides for two classes of membership. Corporate members must be either engineers, contractors or manufacturers of engineering materials or equipment, who have had at least seven years experience in these lines of business, although graduation from an engineering college or university is considered as two years of experience. An associate member [illegible] any person who is interested or

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engaged in engineering construction and has reached the age of 18. However, if he cannot qualify as a corporate member within seven years, his name is dropped from the rolls. Only corporate members have the right to vote and hold office.

The annual dues of the corporate members are to be $10, and of associates $5. The constitution further provides that all applicants making application for membership prior to July 1, 1909, shall be considered charter members, and will not be called upon to pay the entrance fee of $5. During July, 1909, the Board of Directors will pass on all applications, grade the members and refuse admission to undesirable applicants. Meanwhile application for membership can be made to the acting secretary, Mr. Daniel J. Hauer, Park Row Building, New York, and dues can be sent to him.

The following officers of the society were elected: For president, Mr. George W. Jackson, the well known contractor of Chicago; first vice president, Mr. Halbert P. Gillette, consulting engineer, of New York; second vice president, Mr. Daniel E. Baxter, president D. E. Baxter & Co., contractors, New York. Three members of the Board of Directors to serve one year: E Wegmann, consulting engineer, of New York; De Witt V. Moore, vice president of the Moore-Mansfield Construction Co., engineers and contractors of Indianapolis, Ind., and W. D. Lockwood, manufacturer of dump buckets, New York. Directors for two years: George Warren, of Warren Bros., contractors, Boston, Mass.; E. S. Hanson, editor of the "Contractor," Chicago, Ill.; J. R. Wemlinger, president of the Wemlinger Steel Pile Co., New York. Directors for three years: Major Cassius E. Gillette, consulting engineer, Philadelphia, Pa.; F. C. Hitchcock, vice president and general manager McArthur Bros. Co., contractors, New York, and Howard J. Cole, city engineer, Morristown, N. J.

Within 24 hours of the formation of the society a large number of applications for membership were received, two having been sent by telegraph. There seems to be little doubt that by 1910 the membership will be nearly 2,000. The secretary is asking members to remit to him their fees, as the Board of Directors needs money to print the constitution and conduct other business of the society. The directors will have a meeting within 30 days.

The grand total of excavation in the Isthmian Canal for the month of March was 3,880,337 cu. yds. Of the grand total 2,352,903 cu. yds. were removed by steam shovels and 1,527,434 by dredges. There were 27 working days during the month, and the mean rainfall for the month in the territory in which the excavation was in progress was 1.1 ins. The average daily excavation was 143,716 cu. yds.

Concrete and Reinforced Concrete Section

Note:—This section is devoted to methods and cost of constructing concrete and reinforced concrete structures. It will cover the selection, testing and proportioning of concrete materials; laboratory tests of concrete; concrete mixing, transportation and placing; fabrication and placing of reinforcement, and form construction and erection. It will also contain articles on new and interesting developments in the design of reinforced concrete.

A Concrete Plant for Rapid Building Construction.

A decade ago only small buildings were erected of concrete, and when concrete was used in large buildings it was either in the foundations and footings, or for the lower floors. Today, immense structures are being erected of concrete, and we see not only buildings that cover large areas of ground, but also some that are 10 or 12 stories in height. When only small structures were built the handling of the raw materials and of the concrete was a small consideration, but today on large buildings the handling of these materials becomes one of the most important economic problems that the contractor has to solve.

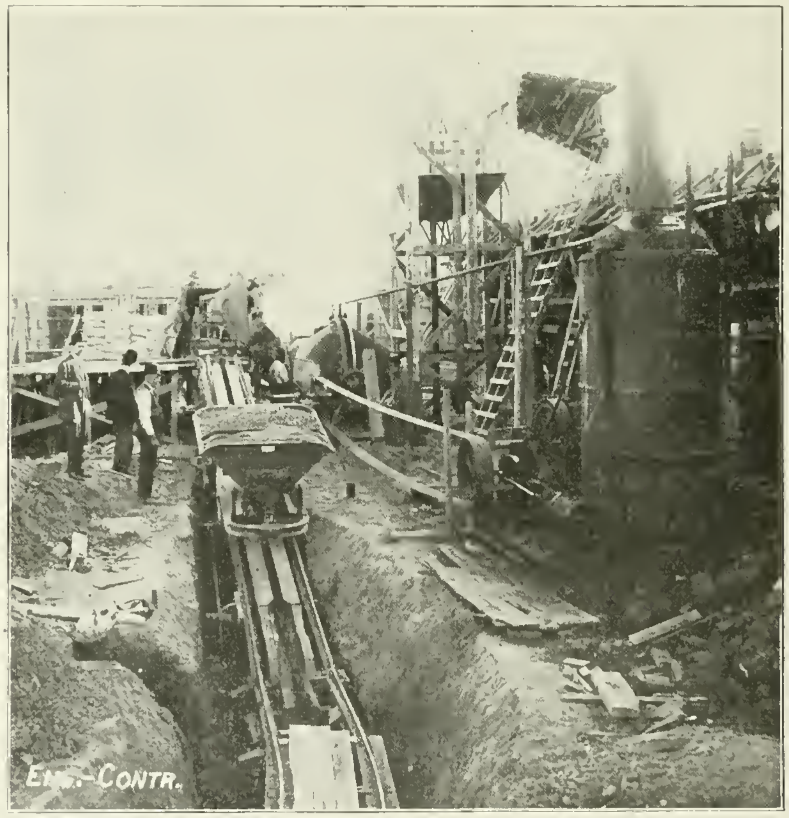


Fig. 1—Arrangement of Mixer, Incline Track and Concrete Hoist Operated by One Engine.

The proper layout of the work and the installation of a plant that will do rapid work and will also save money on the job cannot be decided off-hand, yet we see this being done repeatedly. Our attention has been called to a plant layout for a concrete building that was rather unusual, and, as it was well conceived and not only allowed of rapid work, but greatly reduced the cost of construction over other methods, we give space to a description of the plant and of the method of doing the work.

The building was erected for the United States Printing Co., at East Norwood, Ohio, by the Ferro-Concrete Construction Co., of Cincinnati, Ohio. The architects were Hannaford & Son, of Cincinnati, but the concrete work was designed by the contractors.

The building is one of the largest fireproof factories in the middle west. It is four stories high and has 260,000 sq. ft. of floor space. The building is of re-inforced concrete throughout, on the brick curtain walls. It is designed for a 300-lb. live load on the floors, and they had to withstand a test load of 600 lbs. to the square foot. The girders in the building span 20 ft., and the beams, which are spaced about 7 ft. apart, span 15 ft. The girders of the boiler room span 62 ft. in the clear and are pitched on top from the center to the ends to give the roof its proper fall. All the roof slabs are the Ferro-Concrete Construction Co.'s double air space hollow tile construction, giving splendid insulation and preventing condensation.

The speed of erection of this structure was quite remarkable, as the concrete work was started the beginning of October, 1908, and on Dec. 4, the fourth floor was entirely in place and part of the roof completed. This shows how concrete adapts itself to quick construction, even in freezing weather when properly handled and protected from the weather. On this job they had a 20 H. P. boiler, used exclusively for supplying steam to warm the sand and gravel before it was mixed, also steam connections for warming the water before it was used in the concrete. By a series of curtains, which rolled upon sticks, each floor could be closed in to prevent the cold wind from blowing through, and some 60 salamanders burning coke in this inclosure, with 3 or 4 ins. of straw on top of the concrete, after it was in place, prevented it from freezing in the most severe weather.

Each floor was water-proofed as laid, so that as soon as one floor was finished not only could the brick work be done, but other work could proceed underneath, which was another feature that added to quick construction.

In excavating the foundation the work was done with picks and shovels, and the material was loaded into dump cars, operated on industrial railway tracks, furnished by the Arthur Koppel Co. of Pittsburg, Pa. The track, which comes in sections with the ties fastened to the rails, allows the track to be readily shifted.

The concrete in the foundations was mixed by a Smith Concrete Mixer placed on a large flat car. This car was moved from place to place, and any concrete that could not be dumped directly into place was dumped into the Koppel cars and thus carried to the forms, and then placed. This was found to be both quick and economical.

For all work from the first floor up, a different plant layout was used, and it is among the best that we have ever seen for such a piece of work. A glance at Fig. 3 shows the general features of the layout and the method of handling the raw materials and the concrete.

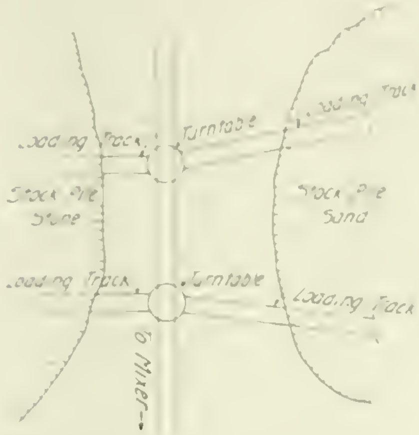


Fig. 2.—Arrangement of Car Tracks at Stock Piles.

The stock piles of sand and stone were at one end of the lot about 300 ft. away from the mixing plant, which consisted of a large size Smith Mixer. An industrial track was laid from the stock piles to the mixer. At the stock piles, two turntables were used in the track and side tracks were run to the stock piles, as shown by Fig. 2, from which the cars were loaded.

The cars were of 40 cu. ft. capacity, 30 in. gauge, and stood 4 ft. 4 ins. high above the rail. Each car had a partition placed in it, dividing the car into two compartments, the smaller compartment for the sand, the larger one for stone. In this manner the materials were measured for each batch.

A trench was cut from the stock piles to the mixer, and in the trench the track was laid so as to get such a grade on the track as to allow the cars to coast from the stock piles to the incline at the foot of the mixer, shown in Figs. 1 and 3. Here an endless chain carried the cars to the top of the incline and to the mixer. The grade on the track from the stock piles was about 2½ per cent. By this arrangement after a man started the car it would coast to the incline leading up to the mixer. The grade from the mixer was about 8 per cent, which allowed the empties to coast all the way from the mixer to the stock piles.

This arrangement was found to be very economical, and illustrates that on a job of some size money can well be spent to instal the proper plant. Although the labor cost of such installation is seemingly high, yet, when it is distributed over the amount of work to be done, the cost per unit is small.

The materials from the cars were dumped directly into the mixer. The cement was stored in a shed adjoining the charging platform (see Fig. 1). The concrete from the mixer was dumped directly into a Wallace hoist, which raised it to the required height, where is was dumped into concrete barrows and wheeled to place.

A single hoisting engine operated the chain on the incline to the mixer and the hoist, and furnished steam for the engine on the mixer. (See Fig. 1.) The hoist discharged its load into a hopper-shaped bin, and from this the two wheeled barrows were loaded.

A duplicate plant was installed on the other side of the building (See Fig. 3) and served in the same manner. With these two mixing plants, 50 cu. yds. of concrete were mixed and placed per hour, without trouble. With this method of delivering the concrete, it was placed in the forms in from one to two minutes after it left the mixer.

Mr. Robert Anderson, Vice President of the Ferro Concrete Construction Co.,

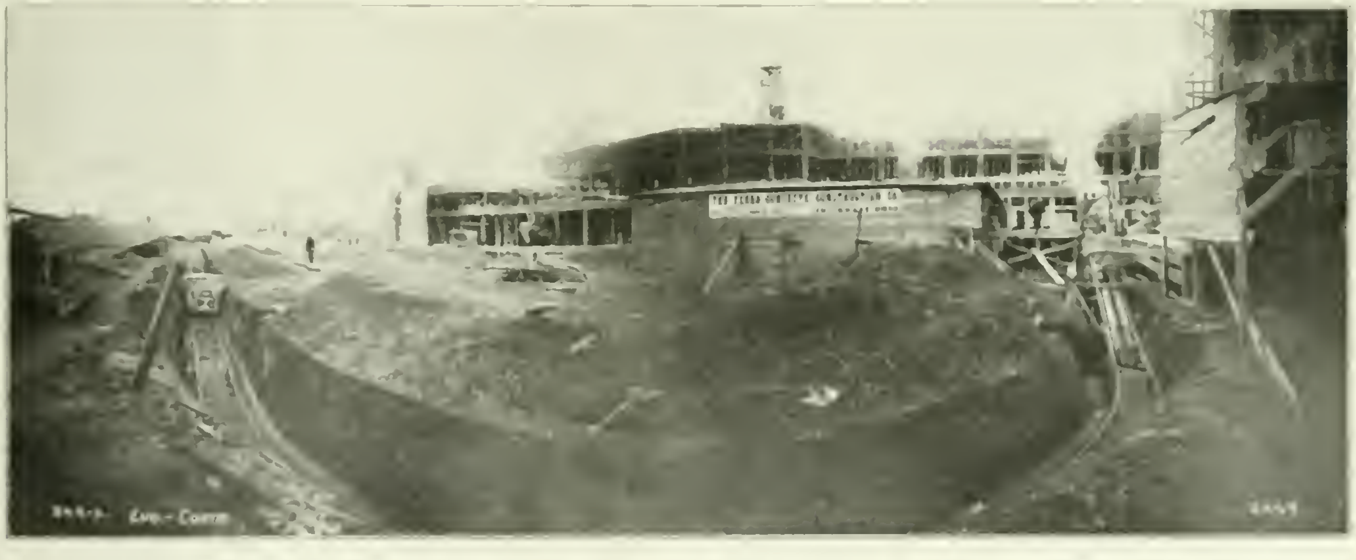


Fig. 3.—General Arrangement of Concrete Mixing and Handling Plant.

states that by using the cars for hauling the sand and stone, the 300 ft. from the stock piles to the mixer, the labor of 16 men was saved, and that by using the cars for charging the mixer the output of the mixer was increased from 50 to 75 per cent above that obtained by charging with wheel-barrows.

Hints for Inspectors of Concrete Work.

III.

Forms for Arch Sections.—See that suitable forms are provided to hold in place sections of arch ring being concreted. If the concreting is done in longitudinal sections see that the forms are set vertical and parallel with the face of the arch. If the concreting is done in transverse sections see that the forms are set in radial planes and straight across the arch at right angles to the faces.

Molds for Ornaments.—See that the molds are so constructed that they can be removed piece by piece without injuring the casting. See that their strength and rigidity is ample to withstand tamping and other strains without distortion.

Time of Removing Forms.—See that forms are not removed until the concrete is capable under the conditions of standing safely without support. The setting and hardening of concrete are variable factors depending on the cement, the temperature, etc., and set rules cannot be made for time of removing forms. Specifications often state the minimum time after concreting for removing forms; where they do not state this time the inspector should ascertain the ideas of the engineer and in important cases had better obtain specific orders from the engineer. The forms should not be removed until the concrete which they support has been examined for hardness; the concrete should not only be hard, but should ring when struck with a hammer. Forms should remain longer under beams and arches than around columns or walls, and longer under beams and arches of long spans than of short spans. Forms should remain in place longer if the weather is cool and damp than if it is warm and dry. To sum up, the time for removing forms is that time when, in the best judgment of the engineer, the contractor and the inspector, they can be removed without injury or danger to the concrete which they support. The following are the times for removing forms practiced by one competent firm of contractors:

Walls in mass work, 1 to 3 days, or when the concrete will bear pressure of the thumb without indentation.

Thin walls, in summer, 2 days; in cold weather, 5 days.

Slabs up to 6-ft. span, in summer, 6 days; in cold weather, 2 weeks.

Beams and girders and long span slabs, in summer, 10 days or 2 weeks; in cold weather, 3 weeks to 1 month. If shores are left without disturbing them, the time of removal of the sheeting in summer may be reduced to 1 week.

Column forms, in summer, 2 days; in cold weather, 4 days, provided girders are shored to prevent appreciable weight reaching columns.

Conduits, 2 or 3 days, provided there is not a heavy fill upon them.

Arches, or small size, 1 week; for large arches with heavy dead load, 1 month.

Method of Removing Forms.—See that the method of removing forms is one which does not jar or chip the concrete or bring sudden shocks on the molded members. See that prying with bars and sledging is not resorted to; if the forms are properly designed and constructed neither is necessary. See that the forms when being taken down are not dropped onto floors and banged against columns and walls. See that a regular procedure is followed in removing forms, and if possible have the work done by regular gangs so that the men become trained in the requirements and methods of the work.

Removing Column Forms.—See that column forms, if removed first, are so removed as not to disturb the beam and slab forms. Column forms may safely be removed considerably before beam and slab forms, and it is wise to do so both to give the air access to the concrete and to enable the columns to be inspected for faults before any load is brought onto them, but if the removal of column forms necessitates loosening or shifting the beam and slab forms they should not be disturbed until it is time safely to remove the beam and slab forms.

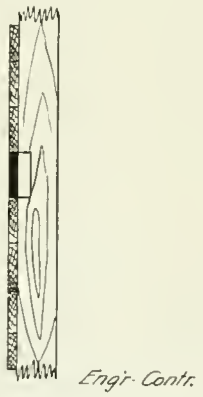


Fig. 1—Sketch Showing a Method of Providing for Swelling of Lagging.

Removing Beam Forms.—See that the bottom of the beam form remains in place until after the side forms have been removed. This permits the sides of the beam to be exposed for inspection and to the curing action of the air without lessening the support of the beam against collapse.

Striking Centers.—See that arch centers are not struck or removed in less than the specified time after concreting is finished. If the specifications do not stipulate this time get instructions from the engineer. See that centers are removed without shock or jar to the arch ring. See that centers particularly for long spans are lowered evenly and very gradually, so as to allow the ring to settle slowly and uniformly. For very long spans the engineer will usually provide special directions for striking centers.

Swelling of Forms.—See that the forms are so framed that swelling will not fracture the concrete or prevent easy removal. For example in molding walls having face panels or moldings, long continuous studs cut to the profile of the wall face will by swelling and the weight of the concrete be difficult to remove without fracturing corners and edges of the panels or moldings. The swelling of lagging, as ordinarily formed, will do little more than "take up" the joints; too well seasoned lumber should not be used for lagging. When dangerous swelling of lagging may be anticipated, a single narrow lagging board may be arranged to be withdrawn after initial set into notches left in the studding (Fig. 1), thus leaving an open space to take up the expansion.

Bracing of Forms.—See that all forms are securely braced: (1) to withstand the loads that come upon them; (2) to preserve their alinement. Bracing is frequently done carelessly and must be watched particularly in regard to its sufficiency to preserve accurate alinement. See that the braces are firmly fixed at the foot and top and that they are stiff.

Location of Shores.—See that shores are not located hap-hazard. They should come at mid-span, one-third span, quarter-span, etc., points. See that shores in each story are located over the shores in the story below.

Length of Shores.—See that shores are cut to proper length for the work. If much too short excessive blocking up is necessitated and the support is liable to be unstable; if too long they have to be hard driven into place with danger to the formwork, the length should be just such that the cap and footing pieces can be placed and the double wedges can be started and tightened.

Square Ends on Shores.—See that the ends of shores are sawed off square so as to have uniform bearing on wedges.

Wedges.—See that uprights supporting centers, girder boxes, etc., are set on double wedges.

Footings for Shores.—See that ample footings are used under posts to distribute the load over soft ground or green concrete.

Caps for Shores.—See that posts used to support floor slabs or beams after the forms have been removed are capped with plank or scantling to distribute the pressure.

Time of Removing Shores.—See that shores for floors, girders, or arches are not removed before the time specified. If time is not specified secure instructions from the engineer. In ordinarily good weather shores should remain in place two weeks, in cold, damp weather four weeks. For extra long spans the time should be longer. The proper time for removing shores is a matter of good judgment, count no precautions to ensure safety.

Method of Removing Shores.—See that shores are removed without shock or jar by pulling the double wedges at the bottom. See that the shores are not removed one at a time and then replaced, this is sometimes done to permit removal of bottom boards of beam molds, etc., before final removal of shores. See that the shore is lowered gently and not allowed to drop heavily onto the floor below. When shores are finally removed see that they are taken out for a beam or a panel at a time; do not permit all the shores under a floor to be knocked down rapidly in succession.

Runways.—See that runways are not laid directly on the steel but are supported above the steel by horses or trestles.

Comparative Tensile, Compressive an Cross Breaking Tests of Concrete.

Tests of concrete by tension are quite rare and any addition to the number is always of interest. Recently some 40 tests were made for the Nebraska Geological Survey at the testing laboratory of the University of Nebraska, and the results have been published by the Survey. Of the 40 tests, 21 were tension tests and the other 16 were divided equally between compression and cross breaking tests. The same mixtures and materials were used in all tests so that the results are comparative in some measure at least.

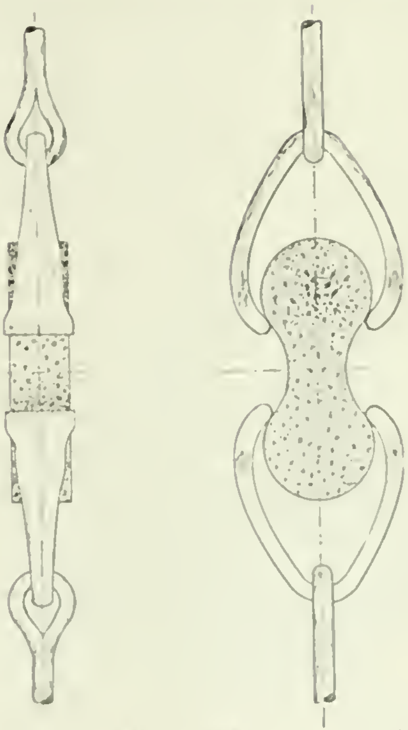
Three mixtures, a 1:2:4, a 1:3:5 and a 1:3:6 were tested, a broken stone and a gravel mixture of each proportion. For tension tests a briquette, Fig. 1, 3 ins. square in section was used. Compression tests were made on the ends of the broken briquettes, as used the compression specimen had an area of 21.6 sq. ins. and a height of 3 ins. The specimens were broken between steel bearing plates without embedding or cushioning. The cross breaking tests were made on 3x6x22 in. bars supported on rounded steel bearings 20 ins. apart. The load was applied at the center. In the tables the breaking strength per square inch is calculated by the formula

$$S = \frac{3Pl}{2bd}$$

Tables I, II and III give the results of the tests.

TABLE I.—TENSION TESTS OF CONCRETE.

Materials	Proportions	Applied loads in lbs. 1 wk.	1 mo.	2 mos.	Av. strength per sq. in. 1 wk.	1 mo.	2 mos.
Watson Gravel Western States Portland Cement	1 2 4	1000	[illegible]				
		880	[illegible]		1[illegible]	198	
	1 3 5	700	[illegible]				
		[illegible]	[illegible]		[illegible]	1[illegible]	
	1 3 6	380	540				
		825	[illegible]		86	1[illegible]	
Weeping Water Limestone Western States Portland Cement	1 2 4	1450	[illegible]				
		1520	1400		182	1[illegible]	
	1 3 5	1110	1340				
		2000	17[illegible]		17[illegible]	1[illegible]	
	1 3 6	1400	1720				
		1030	1[illegible]		1[illegible]	158	
Watson Gravel Red Wing Portland Cement	1 2 4	700	[illegible]	7[illegible]0			
		925	1000	770	9[illegible]	1[illegible]1	[illegible]4
	1 3 5	610	800	950			
		580	1000	650	66	1[illegible]	8[illegible]
	1 3 6	440	900	66[illegible]			
		570	770	62[illegible]	7[illegible]	[illegible]	7[illegible]
Weeping Water Limestone Red Wing Portland Cement	1 2 4	1650	1850	2[illegible]			
		1520	1850	2[illegible]00	148	[illegible]	2[illegible]3
	1 3 5	1100		1250			
		102[illegible]	2000	900	118	222	1[illegible]2
"	1 3 6	745	1[illegible]	1000			
		850	1150	9[illegible]	8[illegible]	164	11[illegible]



Sketch of Grips for Testing Concrete in Tension.

The mineral resources of Japan are being developed along modern lines, although the use of machinery in the mines has not yet become extensive, manual labor being so cheap that the cost of labor saving machinery has deterred its use. The following is a statement of the value of the output of the mines of Japan for the ten years 1897-1906: Copper, $237,174,192; [illegible], $173,134,298; manganese, $[illegible]; silver, $83,102,958; iron, $14,680,062; [illegible], $11,500,059; lead, $15,267,186; petroleum, $1,443,360; gold, $3,069,672.

The Concrete Institute of Great Britain which was founded last year, has now attained a membership exceeding 800, of whom the larger number are members of the Institution of Civil Engineers, Royal Engineer Officers, Architects and Surveyors holding public appointments or practicing in their private capacity. The number of general meetings already held is four, and the next meeting will take place on May 27. The Institute is taking up a strong position in the matter of the proposed amendments to the London Building Acts and has petitioned Parliament on the subject. The first volume of proceedings has already been issued and the second volume will be issued this month. Circular letters with a view to collating information are being prepared on matters affecting the Rusting of Steel, Expansion and Contraction, Algebraical Notation, the Specification of Dampness in Concrete Mixtures, etc. It was originally intended to raise the annual subscription to two guineas per annum for new members at an early date, but it has now been decided that the annual subscription of one guinea shall stand for new members who join this Institute before October next.

TABLE II.—COMPRESSION TESTS OF CONCRETE.

Material	Proportions	Applied loads in lbs.	Average strength lbs. per sq. in.	Age
Watson Gravel Western States Portland Cement	1 2 4	60040		1 mo.
		63000	2760	"
	1 3 5	57100		"
		48700	2400	"
Weeping Water Limestone Western States Cement	1 2 4	71000		"
		70000	3275	"
	1 3 5	62550		"
		105,000	3900	"

TABLE III.—CROSS BREAKING TESTS OF CONCRETE.

Material	Proportions	Applied loads in lbs. Actual	Per sq. in.	Av'ge	Age	Remarks
Watson Gravel Western States Cement	1 2 4	800	17[illegible]		1 week	Tested edgewise
		8[illegible]	18[illegible]	17[illegible]	"	
	1 3 6	160	67			" Flatwise
		1[illegible]	7[illegible]	7[illegible]	"	
Weeping Water Limestone Western States Cement	1 2 4	710	118		"	" edgewise
		1200	200	201		
	1 3 6	400	125		"	" flatwise
		415	130	128	"	

Earth and Rock Section

Note: This Section is devoted to methods and costs of excavating earth and rock and building embankments. It will cover the grading of roads and railroads, diking and canal work, dredging, building reservoirs and earth dams, sewer and water pipe trenching, quarrying, etc.

The Cost of Diamond Drilling for Coal in Pennsylvania.*

BY E. E. WHITE.†

The following notes on progress and cost of drilling in the coal measures of Greene county, Pa., were taken from April 20, to July 13, 1908. I was on the ground practically all of the time, representing the company who had optioned the coal, and so had a chance to obtain correct figures on the progress of drilling. The costs are not as accurate, but are essentially correct.

The cost of superintendence and carbons is estimated. The superintendent, C. C. Hoover, of the Birdsboro Steel Foundry & Machine Co., which concern took the contract for drilling, was on the ground only one day. As he was looking after about half a dozen other drills, the estimated cost for superintendence is liberal. The cost for carbons would have been much less but for the fact that 2¼ carats were broken at a depth of 21 ft. in the first hole, probably by a piece of steel in the hole. This bore was abandoned and another started 2 ft. away.

The drill only worked a day shift, and was run by two men, the drillman, H. N. Wighaman, and a fireman. Bits were set in the company's shop, not in the field. The hours in the progress table refer to the drill, that is, to two men, except in the case of hours setting bits.

The drill had a hydraulic feed and a double-core barrel, taking a 2½-in. core. The outfit, with one good diamond bit, is furnished by the Birdsboro Steel Foundry & Machine Co., of Birdsboro, Pa., for about $3,500.

BOILER AND PUMP TROUBLE.

Considerable trouble was experienced with the boiler on the first two holes, which was accountable for a large part of the hours' delay on these holes, shown by the progress table. The boiler was of the upright type, set behind the machine on the heavy wagon frame. There were no stay bolts, and the flues frequently had to be rolled every three or four days after the first week, and finally were rolled every day for three days in succession. After stay bolts were put in, the flues were not rolled again on the job. Except for the boiler and a troublesome donkey pump which supplied the water tank, the outfit was excellent. The delay on the last hole was mostly waiting for water, which had to be pumped a little over a quarter of a mile.

The expense of pumping on the last hole is not included, as it was borne by the owners of the coal. The contract read that water should be furnished within 100 ft. of each hole. The cost of moving on and off the ground is not included, as it would be variable, according to the distance and means of transportation. The distance moved between holes averaged about a mile by road. It was open country with good roads, so that moving was not expensive.

The core obtained was practically complete, both of rock and coal. The surface was from 6 to 19 ft. deep, averaging 9 ft. to 9 ins. It was clay, with no boulders, and was drilled out with a mud bit.

The table showing rates of drilling in different kinds of rock is the average of many observations on the five holes. The rate is, of course, dependent largely upon the drillman and how much pressure he cares to put upon the bit.

Both cost and progress tables are from the time the drill reached the ground until ready to leave:

BITS USED.

	Distance Drilled.	Estimated Carbon Wear.
Mud-bit	48 ft. 7 in.	
Diamond bit No. 1 (carbons broken by steel?)		2¼ carats
Diamond bit No. 2 (hole No. 1)	369 ft. 8 in.	½ carat
Diamond bit No. 3 (hole No. 2)	339 ft. 0 in.	½ carat
Diamond bit No. 4 (holes Nos. 3, 4)	500 ft. 1 in.	½ carat
Diamond bit No. 5 (hole No. 5)	562 ft. 8 in.	½ carat
	1,820 ft. 0 in.	4¼ carats

RATE OF BORING.

Kind of Rock.	Ft. per Hour Actual Cutting.
Shale	7.05
Fireclay	7.10
Limestone	7.20
Sandstone	9.35
Coal	15.15

COST TABLE.

	Cost.	Cost per ft.
Drillman	$307.70	$0.169
Fireman	192.31	0.106
Blank bits	5.00	0.003
Setting bits	10.00	0.005
Carbons (4¼ carats at $90)	382.50	0.210
Fuel (1,050 bu. coal)	67.17	0.037
Oil and waste	11.00	0.006
Repairs	24.85	0.014
Moving	36.00	0.020
Superintendence	200.00	0.110
Total working cost	$1,236.53	$0.680
Depreciation of outfit (20 per cent on $2,000 for 3 mos.*)	100.00	0.055
Total costs exclusive of freight and hauling on drill and wages and expenses of drillmen to and from Greene county	$1,336.53	$0.735

*The outfit exclusive of the bit is worth about $2,000.

Mr. Hoover, of the Birdsboro Steel Foundry & Machine Co., makes the total cost $1.13 per foot, but I think that figure must be rather high. Four holes put down by the same company in Raleigh county, West Virginia, are said to have cost $2.90 per foot.

PROGRESS TABLE

	Hole No. 1	Hole No. 2	Hole No. 3	Hole No. 4	Hole No. 5	Totals and Averages.
Feet drilled	377.5	358.0	279.4	236.4	568.7	1,820.0
Hours actual cutting	54.44	40.00	35.07	27.45	75.90	232.86
Hours pulling core, lowering rods, etc	38.81	31.00	23.43	18.30	60.85	172.39
Hours drilling	93.25	71.00	58.50	45.75	136.75	405.25
Hours delay, steaming, repairs	66.50	62.25	11.75	18.75	63.00	222.25
Hours tearing down, moving, setting up	20.00	30.00	25.00	20.00	46.75	141.75
Total hours	179.75	163.25	95.25	84.50	246.50	769.25
Hours setting bits	8	4	4	0	4	20
Feet per 10 hr. shift after setting up*	23.60	31.58†	39.83	40.83	28.50	29.97†
Feet per drilling hour*	4.05	5.05	4.75	5.15	4.15	4.49
Feet per hour actual cutting*	6.94	8.95	7.95	8.62	7.50	7.82

†Excludes 20 hours putting stay bolts in boiler.
*Excludes hours setting bits.

A High Cost for Wagon Work and a Lesson.

A contractor in doing grading work often makes a mistake as to the method of doing the work, and unless he is accustomed to keeping detail costs of his daily work, such a mistake may never become evident, especially if the time of doing that particular job is of short duration, or is an insignificant part of the entire contract. Thus the same mistake, although meaning but a small money loss at the time, may be repeated and become a serious matter.

The following cost of a piece of grading done with dump wagons illustrates this point. The work consisted of excavating earth from a borrow pit, to be used in making an embankment on a railroad. The material was sandy with but a little clay in it, yet stiff enough to be loaded by an elevating grader, but easily loosened by plowing, so that a deep furrow loosened a large mass for shoveling. A National elevating grader was used to load National dump wagons, the average lead on the material being about 2,300 ft., thus making an average haul of 2,600 ft. when using a grader, or a haul of 2,300 ft. when loading by hand, the difference being that the wagon must follow the grader to be loaded and must go to one end or the other of the pit to enter and leave it.

When the embankment was about half made, the contractor was compelled to move the grader to another section of the road, in order to hasten the construction

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*Reprinted from the "Engineering and Mining Journal."
†Carterville, Missouri.

there, and in an endeavor to continue the work in the borrow pit, he put a force of men at work there, loading some dump wagons by hand. This was done in the early part of the winter.

A plow was used to loosen the ground, but more than half the time it was employed in plowing for a gang of wheel scrapers in a nearby cut. Only the actual time of plowing is charged against the wagon work. About 12 men did the shoveling, and as the material was dumped in layers on the embankment two men were used to spread the earth. Seven wagons were used in the run.

The following wages were paid for a 10-hour day:

Foreman	$3.00
Laborers	1.50
Wagon, team and driver	5.00
Four-horse plow team	9.00

The work was continued for 17 days, the gang excavating in that time 1,293 cu. yds.

The daily cost records from the start showed a high cost, and although every effort was made to reduce these costs, and they were reduced somewhat from day to day, yet at the end of the 17 days they were still so excessive that it was decided to withdraw the gang and wait until the grader could be put back into the borrow pit.

The cost of doing the work was as follows:

Foreman, 17 days	$51.00
Laborers, 201 days	301.50
Wagons, 125 days	625.00
Plow, 7 days	63.00
Dump men, 36 days	54.00
Total	$1,094.50

This gave an average cost per cubic yard of the following:

Foreman	$0.040
Loading	0.233
Hauling	0.483
Loosening	0.048
Spreading on dump	0.042
Total	$0.846

It is evident that this is a high cost. An analysis shows that each man shoveled 6.4 cu. yds. Working against a breast and casting into dump carts, a man should have loaded from 12 to 13 cu. yds. of this material in 10 hrs. Each man on the dump spread 36 cu. yds. of earth in 10 hrs.

Each team traveled on an average of 10 miles per day and hauled about 11 cu. yds. About 1 cu. yd. was hauled to the load, place measurement, although the wagons were of 1½ cu. yd. capacity. These figures show that the great trouble was in the gait set, both by a few men in loading and by the teams in making a fairly long haul. The loading was slow, so the teams, not being pushed, traveled at a slow pace.

As soon as the grader was put to work the wagons were loaded quickly, they went off to the dump at a faster pace, and a toot from the traction engine pulling the grader caused them to come back from the pit at a trot. A large number of wagons were used with the grader, and there was bound to be much greater interest and enthusiasm in the work and the rate at which it was done.

This is evidenced by the cost of excavating a yard of the material with the grader, which was as follows:

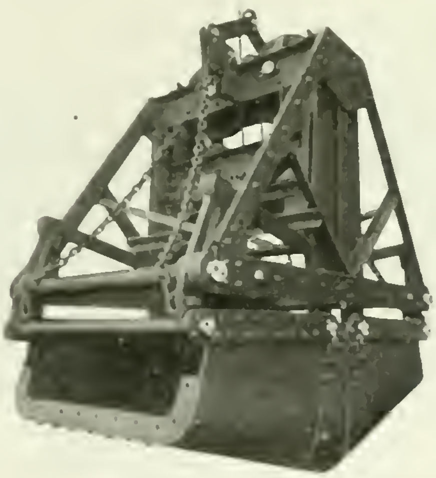
Foreman	$[illegible]
Loading	[illegible]
Hauling	[illegible]
Spreading on dump	[illegible]
Total	$[illegible]

This shows a saving of over 52 cts. per cu. yd., and yet the grader excavated only 400 cu. yds. per day, as it frequently had to wait on the wagons to return from the dump.

A Clam Shell Bucket with a New Closing Action.

A notable feature of the clam shell bucket shown by the accompanying illustration is the special arrangement of closing mechanism by which the digging and closing force is progressively increased as the jaws come together. This feature makes the bucket a type of its own. As will be seen from the illustration, the bucket is simple in construction, being made almost entirely of flat steel bars and plates. The only castings are the bell cranks and the sheaves, and these are steel castings. The sheaves are bronze bushed. The bell cranks give a very wide jaw opening.

The main links which connect the inner edges of the scoops to the cross head are made of plate steel with separators between them, thus making a very strong section against bending, and in addition to this there is lateral bracing connecting the arms with those on the opposite side of the scoop so that the scoops can not get out of alinement.



Clam Shell Bucket with New Closing Action.

Another feature of great importance is that the sheaves and all the working parts are always well out of reach of the material, thus eliminating all undue cause for wear and tear on ropes and mechanism.

The bucket is opened by a positive opening device by means of chains connected from the back end of the scoop to the small bell cranks at the top of the upper frame to which the holding cable is attached by links, the variation in height when bucket is open or closed being but a few inches instead of a few feet, as is generally the case with buckets having a positive opening device. The arrangement of the sheaves is such that they can be removed without disturbing any other part and the cable can be reeled in in the shortest possible time.

The bucket is manufactured by The Peerless Engineering Co., 221 Rockefeller Building, Cleveland, O.

According to estimates of the Division Engineers of the Isthmian Canal 9,272,000 lbs. of dynamite will be required for canal work in the fiscal year 1910. The estimates have been embodied in a requisition and bids will be requested in a few days. The requisition is divided among divisions and into classes as follows:

	Pounds	Pounds
Dynamite, Saltpetre, 60 per cent Nitroglycerine		
Atlantic Division	982,000	
Central Division	1,800,000	
Pacific Division	600,000	
		3,382,000
Dynamite, Saltpetre, 45 per cent Nitroglycerine		
Atlantic Division	225,000	
Central Division	5,400,000	
Pacific Division	200,000	
		5,825,000

The size of the cartridge for the above is to be 1¼ ins. diameter by 8 ins. long.

Dynamite, Saltpetre, 45 per cent Nitroglycerine	
Pacific Division	5,000
Dynamite, Saltpetre, 60 per cent Nitroglycerine	
Pacific Division	60,000
The size of the cartridges for the above is to be 2 ins. in diameter by 16 ins. long.	
Total	9,272,000

The conditions on which the contract is to be awarded are:

The Commission reserves the right to increase or reduce the amount of dynamite to be furnished by 20 per cent at any time before shipment is made. The delivery of the 45 per cent and 60 per cent dynamite in cartridges 1¼ ins. by 8 ins. is to be made in monthly shipments extending over a period of one year. The delivery of the 45 per cent dynamite and of the 60 per cent dynamite in cartridges 2 ins. by 16 ins. is to be made in one or more shipments as early as possible after August 1, 1909. All the explosives are to be packed in moisture-proof cases of 10 lb. cartons, in 50-lb. wooden boxes, cartridges to be wrapped in a bituminous cover of paper and stamped "I. C. C." in conspicuous red letters. Bids will be received for Trojan powder and Nitro powder equivalent in disruptive effect to the grades of nitroglycerine dynamite herein specified. Bidders on such explosives must guarantee the performance of their explosives and that the safety and keeping properties of the same will be equal to those of the equivalent grades of dynamite, and that they will prove in all other respects equally efficient and satisfactory for use on the Isthmus.

Roads and Streets Section

Note: This Section is devoted to methods and costs of road and street construction. It will cover road building in all its details, the construction of pavements, sidewalks and gutters, the testing and use of paving materials and the machinery and tools used in road building and paving.

A Labor Saving Device for Handling Brick to Pavers from Stock Piles Without Breakage.

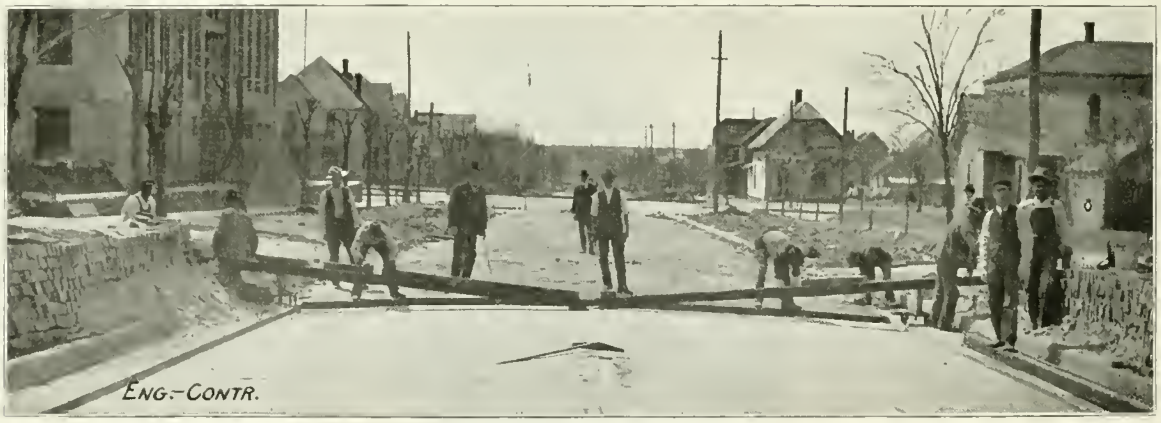
The accompanying illustration shows a simple device for handling paving brick from stock piles at the sides of the street to pavers, which has been successfully used by Carlson & Theselius, brick paving contractors, Chicago, Ill., in paving work in Chicago and other western cities. The usual method of handling brick is by wheelbarrows. The barrows are loaded at the stock piles by wheelers, wheeled onto the street and dumped. There the dumped brick are arranged ready to the hand of the pavers by pilers. For say three pavers laying 1,500 sq. yds. per day there will be required eight wheelers and four pilers to handle the brick. In addition the loading and dumping of the brick results in a great deal of breakage. With the device illustrated it has been found easily possible to supply bricks to three pavers laying 1,500 sq. yds. per day with only four men, a saving of eight men over wheelbarrow work.

The general arrangement of the device on the work is shown by the illustration. The device is merely a set of conveying rolls. Two boards 5 ins. wide are set parallel and carry between them a train of wood spools. The axles of the spools extend through bushed holes in the side boards and have removable nuts at the ends, which permit oiling. The spools are spaced so as to have a clearance of ⅛ in. They are ordinary wooden spools, with a barrel 3⅜ ins. long between shoulders. They are set so that the line of the shoulders is just below the top edges of the side boards; this permits a steel strap guard to be fastened to the top edge of each side board so as to extend inward over the shoulders and prevent dirt and chips from lodging between the ends of the spools and the adjoining side boards. Below the journals the side boards are thinned down so as to permit such debris to fall out easily. The whole construction is very simple and forms, as has been stated, a train of rolls which, when set at an incline, will allow a brick, when set edgewise on the spools, to move from top to bottom by gravity.

The conveyors described above are usually made in 16-ft. lengths. They may, of course, be made longer, but a 16-ft. length is easily carried by one man, and when much longer conveyors are needed two or more 16-ft. sections can be coupled end to end. When used on the street the ends of the conveyors near the sides of the street are supported on standards extending up from small trucks or carriages which travel along the gutter. This method of support can be seen in the illustration. Two conveyors are employed, one extending into the street from each side. The inner ends of the two conveyors meet at the center of the street and the outer ends extend beyond the supporting trucks and the gutters and past the ends of the stock piles. Just back of the trucks there is a hinge in each conveyor which permits the projecting end to be tilted up to clear trees, poles or other obstructions when the conveyors are shifted ahead. The incline given the conveyor is as flat as may be, so that the brick can be put on and taken off the conveyor with as little lifting as possible. An incline of 1 in. to 1 ft. is ample; in fact it has been much flatter on most of the work done by Messrs. Carlson & Theselius. In one case the incline was only 14 ins. in 24 ft.

The method of operating the conveyors is quite clearly shown by the illustration. The loaders take the bricks from the piles and set them edge up and endwise on the spools. The movement of the brick is then by gravity down the conveyor. In putting the brick on the conveyor the loaders take care to place the best or smooth edge up, so that when the pavers take them off they do not have to turn them to find the best edge to come on top. The pavers grasp a brick in each hand and place both at once. The loaders take care, in placing the brick on the conveyors, to keep the supply just ahead of the laying. If the conveyor is kept tight packed with brick all the time, they bind and the paver has to exert more force in lifting them, which reduces his speed.

As stated above, with three conveyors a gang of seven men, four loaders and three pavers, will lay 1,500 sq. yds. of paving a day. This record has been frequently made by the contractors named above. These contractors have patented the device and are putting it on the market. They will furnish these conveyors made up in 16-ft. lengths or longer at $2 per lineal foot.



Handling Brick from Stock Pile to Street by Conveyors in Brick Paving Work.

The Theory of Economic Road and Street Design and Location.

(II.)

Estimating Probable Traffic.—We have seen the fundamental importance of estimating the probable traffic, the application of an economic theory of road or street design being impossible without a traffic estimate. Let us now consider the two methods of estimating traffic: (1) By a traffic census; (2) by a traffic survey.

Traffic Census.—In order to determine the attrition to which a pavement is subjected, it is customary to count the number and kind of vehicles that pass across a given section of the pavement during a day. Such a traffic record is called a traffic census. On first consideration, this seems to be the only investigation of traffic that is necessary before proceeding with the design of a pavement. However, while such a census is important in order to forecast the wear of the pavement, it is of minor importance compared with a traffic survey from which the annual ton-miles of traffic can be ascertained.

Traffic Survey.—We have coined this expression to designate the process of ascertaining the total number of tons of produce to be hauled and the average length of haul.

Whenever a new railway is intelligently projected a traffic survey of its tributary territory is made. The engineer determines the approximate number of acres of productive tributary land, and estimates not only the tonnage that it is actually producing but what it is capable of producing when adequate transportation facilities shall have "developed" the country. The average length of haul by rail is then estimated, and the probable gross revenue to the railway is thus predicted.

In building a new road and in improving an old one the same sort of a traffic survey should be made. The engineer should plat upon a map the areas of different farms, and show what kind of crops they are producing, the number of acres to each crop and the average tonnage yielded per acre. The distance from each farm to the point of final delivery on the highway should then be estimated, and the ton mileage ascertained.

A second estimate should next be made, showing the probable tonnage that may be developed on this same land when lower costs of hauling shall have made the farming of other products profitable, or when uncultivated land shall have been put under cultivation, or when intensive farming shall have taken the place of existing farming. Such an estimate will serve to indicate the development that may be expected to follow within a moderate time after the building of the highway. Highways, like railways, are built not merely to accommodate existing tonnage but to develop new tonnage—a fact that many short sighted people seem not to perceive.

Estimating Average Hauls.—The haul is the distance from the point of loading to the point of delivery of the load.

If a road is 10 miles long, it does not follow that the average haul is 5 miles, for it may, and often does, happen that most of the tonnage is located near one end of the road.

To ascertain the average haul of the total tonnage, multiply the tonnage on each farm by the distance of that farm to the market, add these ton-mile products together and divide by the total tonnage; the quotient is the average haul.

If we have 100 tons hauled 2 miles, 80 tons hauled 3 miles and 120 tons hauled 4 miles, the average haul is found thus:

100 × 2 = 200 ton-miles
80 × 3 = 240 ton-miles
120 × 4 = 480 ton-miles
———
300 920 ton-miles
920 ÷ 300 = 3.07 miles average haul

Since it is usually convenient to reduce all costs (such as interest, maintenance, etc.) to the mile of highway per year, it is desirable to ascertain the ton-miles of traffic per mile of road. It is not necessary to calculate the total ton-miles, as above indicated, in order to arrive at the average number of ton-miles per mile of road, as will be seen from a consideration of the following rule:

Estimate the total number of tons (not the ton-miles) to be hauled from the entire territory tributary to the road and divide by 2; the quotient is the average ton-miles per mile of road.

Performance of Teams.—A horse is capable of exerting a steady tractive pull, when going at a walk, equal to one-tenth its weight, for ten hours. Thus, a 1,200 lb. horse will exert a steady pull of 120 lbs. on the tugs all day long, walking at a gait of 2½ miles an hour (220 ft. per min.) on a hard, level road. This is equivalent to

120 × 220 × 600 = 15,840,000 ft. lbs.

Not within recent years have any experiments been published regarding the number of foot pounds of useful work done by horses; but certain old English and French tests indicated that the number of foot pounds of useful work done by horses is tolerably constant whether the working day be long or short. In brief, if a 1,200 lb. horse were required to work only 300 mins. (5 hrs.) a day, it could still perform about 16,000,000 ft. lbs., and, of course, to do so it would double either its tractive pull or its speed. It is an established fact that, where the foothold is good, a horse can exert 4 times its normal pull for a short time, or that a 1,200 lb. horse could exert a pull of 480 lbs.

This ability of a horse to exert more than its normal pull has a decidedly important effect upon the theory of road location, as we shall see when we come to the discussion of maximum grades.

When a horse is required to walk all day on soft earth or in deep mud, its effective pulling power is greatly decreased, for it is forced to raise its own weight to a greater height every step it takes than when it is walking on a hard surface. This consumption of energy greatly reduces the otherwise available 16,000,000 ft. lbs. of work. According to the writer's experience, about 16 miles is a good day's work on soft ground instead of 24 miles on hard roads. In mud it is considerably less.

When traveling at a trot a horse raises his body to a much greater height each step than when walking, and thus consumes the available 16,000,000 ft. lbs.

Estimating The Value of Team Time.—There is probably not a single farmer living who has ever studied the economics of hauling with sufficient thoroughness to know the value of team time. Yet there are engineers who have attempted to measure "the farmers' view" of road improvement on the ground that farmers ought to know best how much money can be profitably expended in road building. A railway engineer will find it just as profitable to consult a farmer when projecting a railway, as will a highway engineer when projecting a road—and no more. Problems in transportation are engineering problems, even though the motors used to effect transportation are in the hands of farmers themselves.

In his book on "Roads and Pavements," Baker says (p. 16) that on asking farmers what it was worth to haul crops to market, the answer was usually arrived at by counting the price of team, driver and wagon at $3.00 to $3.50 a day. "On changing the form of the question and asking, 'What does it really cost you?' the answer is almost invariably 'Nothing.'" By this citation of farmers' answers, which is made to prove that team time after the harvests are harvested is of nominal value, Baker proves the utter worthlessness of such testimony on matters pertaining to road economics, although his intention was exactly opposite.

The Illinois Agricultural Experiment Station sent out a bulletin to farmers and received 316 replies to the effect that the average price of a team and man during the crop season was $2.13, which again illustrates the incompetency of farmers to testify in such matters.

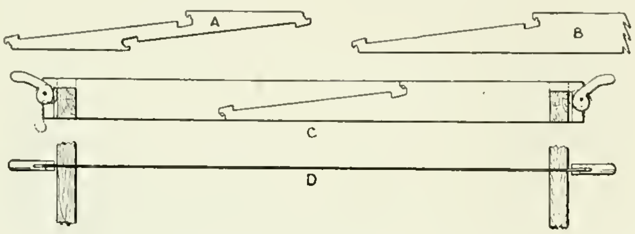
The average man, and even many engineers, when asked the daily cost of operating a machine, will make an estimate of the daily wages, daily coal and average daily current repairs. This is erroneous enough even for a machine that does not consume coal when it is not working, but the error is greatly multiplied when the machine is a horse that consumes food on Sundays, holidays, rainy days, and all days of the year. Interest on the investment, and at least part of the depreciation of every machine and working animal are likewise accumulating charges that do not cease during the days that are not worked, but continue to operate every day of the year. Hence no method of estimating the cost of operating a machine or an animal per day worked is even approximately correct unless it is arrived at by taking the total annual expenditure (including average annual depreciation ascertained from a long term of years) and dividing that total annual expenditure by the average total number of *days actually worked* per year.

In the northern parts of America the working season for outdoor construction is frequently not more than 7½ months long. This is so of all work that cannot be done until the frost is out of the ground, and roughly covers the period between April 15 and Dec. 1. In this period there are 190 working days, but rain will usually eliminate 10 per cent of these days and leave about 170 days actually worked in certain classes of outdoor work. Where such is the case it is clear that the cost of feed (for example) for the 365 days must be divided by 170 to arrive at the cost of feed per day worked. Contractors who make a business of hauling are well aware of the importance of estimating the value of a working team day in this manner. If they were not, they would soon cease to be contractors. Farmers, on the other hand, are rarely well enough informed on cost data to make even an approximate guess.

An Adjustable Form Holder and Cross Form for Cement Sidewalk Work.

Competent form setters are one of the scarcest kinds of laborers to obtain for sidewalk work, and next, perhaps, to finishing, form setting is the kind of work which calls for the most skillful and rapid workmen. Any device or method of operation which will reduce the time and skill required in setting sidewalk forms is, therefore, of interest. Recently the Concrete Construction Co., Houghton, Mich., contractors, has been using a steel combination cross form and form holder which has proved to be a material aid in its cement walk work. This device is shown by the accompanying drawing, and the following description of its construction and of the method of using it have been prepared from information furnished by the company.

Construction.—As shown by the drawings, the device consists of a steel plate cross form or parting strip which clamps together the side forms and holds them to the proper distance apart. It does away with practically all stakes. The cross form is composed of interlocking sections of steel plate 4 ins. wide, 3/16 in. thick on top and ¼ in. thick on the bottom, the wedge shape being adopted to facilitate withdrawal. A complete form consists of seven sections, two of which are end sections, as shown at *C*, and carry the clamping device; the others are intermediate sections of the general shape shown at *A*. The special end section *B* is for use in place of the regular ends when the walk comes close against a fence or building and there is no room for the regular side form. The teeth permit the end of the section to be fastened by driving to the baseboard of the fence or building. The seven sections are not generally used at one time, but they can be connected up when necessary to construct very wide walks. The two end sections alone, make a cross form for a 3-ft. walk, and by adding one or more intermediate sections the length of the plate is increased by increments of 6 ins. up to walks 14 ft. wide. The method of interlocking the sections is clearly indicated by the drawings; to fasten the interlocked sections together, 3/16-in. copper rivets are driven and headed in the two countersunk holes shown by the small circles in drawing, *C*. To take apart the sections these rivets are driven out with a hammer and punch. Any workman of ordinary intelligence can, it is stated, do the riveting rapidly and without trouble. It will be noticed that the end sections are slotted to slip over the side form boards, which are in turn notched with a saw cut, so that the top of the plate comes down flush with the top edges of the side forms and does not interfere with the use of straight-edge or trowel. The cross forms are tightened to clamp the side forms by simply turning the cam handle.



Form Holder and Cross Form for Cement Sidewalk Construction.

Method of Setting Forms.—In setting forms the wooden 2x4s, or whatever is used for side forms, are strung along the walk on both sides, so as to break joints. The saw cuts are then made about an inch deep in the top edges and at intervals corresponding with the block lengths being used. The cross forms are then inserted in the saw cuts and clamped and the whole form is ready to level up. Use one set of stakes for both line and grade, and set them from 1 to 3 ft. outside of the walk and from 25 to 50 ft. apart. Level up the side form nearest the stake first and block it by kicking earth beneath it every few feet. Line up the side at the same time that it is leveled. Next level the back form from the front form, giving it whatever superelevation is wanted for the pitch of the walk. The form is now ready for concreting. In placing the concrete it is well to deposit one or two shovels full in each corner of the block and midway of the cross form on each side, to anchor the form before dumping wheelbarrows in the center. After the concrete is all in and tamped, stretch on and straight-edge off the top coat. When ready to finish, do all the necessary floating and troweling. Then run an edger along the side forms between cross forms. Next run a pointer along each side of the cross form plate to loosen the top material. Unlatch the cams, and, using the handles, lift the cross form first with a short quick jerk and then by raising it slowly. As soon as the cross form is out, run the jointing tool in the space left by the plate and round down the edges of the joint.

As to number of cross forms to be used, and progress which will be made, practice will of course vary. For say 2,000 sq. ft. of walk a day the company named above uses about 45 cross forms. This gives 10 to 15 for the form setter to be setting up, 10 for the concrete gang to be working on, 10 for the top stuff men to be striking off, and 5 or 10 for the finisher to be working on. One man has been able to set the forms for a gang laying 2,000 sq. ft. a day. In addition it was possible to drop one man from the gang, owing to the fact that there were no joints to be cut. There was also the saving of stakes, nails and braces required where all-wood forms are used.

This steel combination cross form and form holder has been put on the market by the Concrete Construction Co., of Houghton, Mich.

Notes on the Wear of Macadam and the Selection of the Top Course.

In his last annual report the Engineer of the Middle Division, New York State, gives some notes on the wear of macadam roads in that division.

It was found that the harder grades of limestone furnished a very satisfactory surface for medium to light travel, say up to 80 vehicles per day. With travel over this amount the surface soon wears away into dust. On the Chenango River Road in Broome County, with an Onondaga limestone surface and a daily traffic of about 120 vehicles, the wear on the macadam was about ½ in. in depth per year, the surface remaining smooth and true at all times with very little mud. Hudson River traprock was used on two roads in Onondaga County that were improved in 1899. Both have about an equal traffic, 160 vehicles of all kinds in nine hours, and the total wear on the surface for 8 years ranges from 1 to 1½ ins. in depth for the center 8 ft. of the macadam to but ½ in. on the edges of a 15-ft. width. The soft sandstone of the southern counties has been used for macadam surface in some instances. On one road in Chenango County, improved with local stone, with a daily traffic of 85 vehicles of all kinds, the wear was 1 in. in depth per year, and in 2½ years had to be resurfaced. The top course of macadam on this road was formed of fragments ranging from ½ in. to 2 ins.

The results obtained on the Middle Division, states the report, would indicate that the size of the stone forming the top course influences the wear to a considerable extent, and that the size used should vary with the texture of the rock and with the amount of traffic. For traffic of 100 vehicles, or less, per 10 hours, if the macadam is formed of soft sandstone, the top course should be of fragments ranging from 1½ ins. to 2½ ins.; if formed of limestone, from 1 in. to 2 ins.; if trap-rock is used, from ½ in. to 1½ ins. If the traffic is over 100 vehicles and less than 200 in 10 hours, the top course should be formed of trap-rock, granite or syenite, ranging from 1 in. to 2 ins. in size. If traffic is over 200 vehicles and less than 500 in 10 hours, the top course should be constructed of trap-rock, ranging from 1½ ins. to 2½ ins. If traffic is over 500 vehicles in 10 hours, macadam is not suitable for road surface.

Unclassified and General Articles

Note: This section is devoted to methods and cost articles on construction work not properly coming under any of the preceding classifications.

General Instructions to Locating Engineers Alaska Central Railway.*

The following very complete set of instructions to locating engineers were prepared by Mr. G. A. Kyle to govern the location surveys of the Alaska Central Ry., during 1904-5, from Seward northeast toward Fairbanks. Mr. Kyle was engineer of surveys. The directions are as follows:

PRINCIPLES

1. Reconnaissance must not be on a line, but of an area, including as wide a belt on each side of an air line between two fixed termini as there is any possibility of the line reaching. Prepossessions in favor of the most obvious routes must be set aside, especially those lying close to highway or the open districts.

2. Lines hard to traverse on foot seem worse than they really are. Raggedness of detail, sharp rock points, steep bluffs, and the like, extending over short distances, exert an undue influence when compared with long rolling slopes stretching for longer distance.

3. Routes will be compared on the basis of total cost and operating value. Short sections of expensive work may, when averaged with the balance of the line, show a less cost per mile than another line of more uniform character.

REPORTS, FIELD AND OFFICE WORK

4. The reconnaissance report should show the main features of the region and contain the elements affecting operation and construction cost. The engineer should separate the routes reported upon into natural divisions, giving the distance, grades and controlling points of each. He should describe and approximately classify and estimate the work to be done, giving average per mile and totals for each section and furnishing an approximate estimate of the cost per mile and total cost of the completed railway.

5. The engineer will keep a diary in which he will enter all items of interest pertaining to the work. From this reports with sketches, profiles, etc., will be made up and transmitted to the Engineer of Surveys on the 1st and 15th of each month or at such stated time as he may indicate.

6. A complete sketch map of the water courses and divides will be made as the reconnaissance proceeds, sufficiently exact to enable the Engineer to state positively whether and where the water of each stream crossed joins another, until both have passed off the limits of the area under examination. On this map the water sheds should be outlined, with the location of all low divides.

7. Engineers will make the preliminary reconnaissance in person, using prismatic compass, odometer, pedometer, hand level and aneroid, as they may be required. When there are several routes, this process will usually eliminate one or more of them from further consideration. The first step is to obtain the best available maps of the country, such as those of the U. S. Geological Survey.

8. Where reliance is to be placed on barometric elevations, two well adjusted barometers should be used, one of which is to be kept at a fixed station at some convenient point, while the other is to be carried over the route. Observations of the fixed barometer should be made every half hour, and from them a daily curve platted. Observations with the line barometer should always be timed so that its readings may be platted on the daily curve sheet, and the true difference of elevation thus obtained.

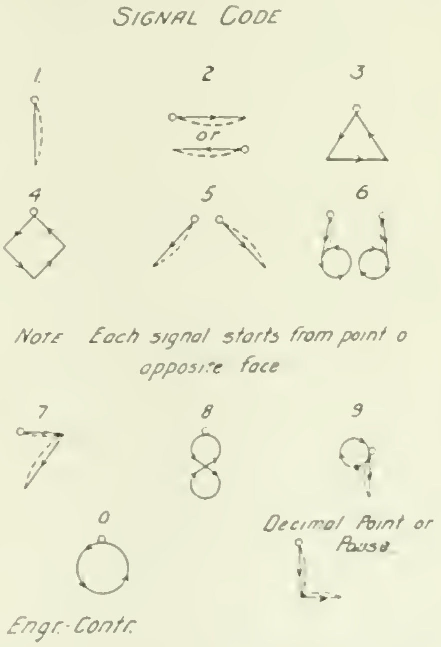


Fig. 1—Signal Code for Stadia Surveys.

EXPLORATION LINES AFTER RECONNAISSANCE HAS BEEN MADE

9. The exploration line should be run as rapidly as possible over the entire route. In case of very long lines, circumstances may make it necessary to carry on and complete the surveys by sections, but this should, if possible, be avoided.

10. The purpose of the first line should be merely to get a general idea of the topography of the country, and especially of the gradients, and it should be run over all feasible routes in the vicinity of the line under construction when there is a reasonable doubt. No attempt to study the location in detail should be made, but the most favorable ground in the vicinity should be selected.

11. A full scale profile of the ordinary form may sometimes be necessary, but not usually for the entire distance.

A small scale profile, 1,000 ft. to the inch horizontal scale and 100 to 200 ft. to the inch vertical scale (depending on the nature of the ground), and showing elevations, ruling grades and general features, should in all cases be made.

12. Small scale maps should accompany and explain the profile. As a rule for all surveys, maps should not be made to a larger scale than will show the smallest details of frequent occurrence; 1000 ft. to an inch will generally suffice for this purpose. Occasional details may be shown enlarged on one side of the map, it is not necessary to increase the scale expressly for them. Condensed maps and profiles enable one to get a better grasp of the problem in hand. Exploration lines should always be run with angles measured by transit, instead of compass, as the compass is unreliable, although compass readings should be taken to check the angles for direction. Stadia readings may be used to obtain both distance and elevations. This facilitates the immediate determination of controlling points within the area studied.

STADIA LINES

13. Stadia tables and a 10-in. stadia rule are a great convenience. All points occupied by the transit should be marked by hubs, which are necessary as reference points in future work. Whenever possible, locate hubs where they may be readily found and at the same time are not liable to be disturbed, as, for instance, close to fences, walls or trees, which latter should be blazed.

14. As general signals for moving rod men into position, etc., in stadia work the following may be used. They depend on two principles.

First. The signal for each figure starts from a point directly in front of the eyes and returns to the same point to complete the signal.

Second. It is a matter of indifference with which hand the signal is made, or whether the motion is direct or reverse.

For considerable distance a handkerchief may be held in the hand while signaling.

Each number should represent a prearranged phrase as in telegraph codes. Thus 17 might mean "Hold on crest immediately behind you"; 19, "Hold in bottom of creek"; 21 "Hold on fence corner," etc.

In the diagram the mark "o" indicates the initial point, and the dotted lines the return trip to the starting point.

These signals are also useful for setting the target and recording the exact elevation of same in the usual method of leveling with Philadelphia rod.

15. In stadia lines, as elevations by ver-

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*Extract from a paper by G. A. Kyle before the Pacific Northwest Society of Engineers.

tical angles are of the greatest importance, the engineer should see that he is provided with a good transit, so that all vertical angles can be checked by reversing.

LINE SURVEYS.

16. Before the survey of any route is commenced, the Locating Engineer will receive instructions from the Engineer of Surveys as to the gradients and curves to be used on the survey, the basis of comparing the desirability of and equating the operating value of different lines between common points, and such other instructions as may be needed for his guidance.

17. Engineers have immediate charge of surveying parties and are expected to see that their parties are well supplied with instruments, tents, stationery, provisions, and all tools that are needed for the proper and vigorous prosecution of their work.

18. First project the route of best grade and alignment, working back to the final and most economical route, with due consideration for side lines which avoid heavy work for short distances, and which may serve temporary purposes. But all surveys should be made with regard to future permanent construction and every effort used to reduce the amount of temporary construction which may be required to the least limits.

Note that the really vital and dangerous errors of location, such as the selection of the general route, the system of gradients, the passing by of local towns or sources of revenue, are usually committed in running the preliminary lines.

19. Every effort should be made to maintain the lowest practicable and economical rate of grade over the entire engine district.

20. When sections of high grade are unavoidable, try to concentrate the "rise and fall" into short sections for operation by assistant power.

21. Adjust the ruling grades of each engine district with reference to those of the adjoining districts, and to conditions of local traffic, and thus avoid "breaking and making up of trains."

22. On sections to be worked by assistant power, produce the maximum and minimum ruling grades to an intersection, if possible.

23. Pusher grades should be designed if possible so that road engines can be used as pushers and haul the train that can be handled on the maximum minor grades on the divisions adjoining them.

Note.—To find the net tons behind the tender that a locomotive will haul on a given grade, multiply the weight on drivers by 22% and divide the product by 20 times the rate of grade plus 6. This will give the gross tons, and subtracting the weight of the engine and tender will give the net tons the engine will haul. For a Typical engine figure 70 tons on drivers and total weight of engine and tender 130 tons.

Example: What net weight of train will an engine with 70 tons on drivers haul up a 2% grade?

$$\frac{140000\times.22}{(20\times2\%)+6}=670\text{ tons}-130\text{ tons}=540\text{ tons.}$$

24. Engineers will keep a diary in which they will enter every evening a record of the day's work. This diary should contain everything of value noted during the day. It should be turned in, with the balance of the notes, when the survey is completed. It will form the basis for a semi-monthly report, which the engineer will furnish, stating progress and giving all other items of general interest pertaining to the work, with reasons for running the various lines, etc., particularly noting traffic possibilities.

25. These reports should be illustrated with small-scale maps, sketches, condensed profiles, etc. They should show number of days' delay or time lost, with reason for same. They should be sent promptly to the Engineer of Surveys on the 1st and 15th day of every month.

26. The engineer will note in his diary and on the map objects near the line that should be avoided and will give his opinion in the report of how his line may be changed, shortened, or otherwise improved, noting particularly the physical differences between the two sides of the same valley and their effect on the cost of construction and operation, and make full comparisons of the relative merits of the different lines.

MAPS.

27. Make all maps on a scale of 2,000 ft. to the inch, unless otherwise instructed.

28. Place top of paper to the northward or westward, considering the general direction of the road, and the letters are to be right side up when looking toward the top or toward the left-hand side of the paper.

29. The map should be made on paper or tracing cloth 21 ins. wide, or one-half the width of the paper or tracing cloth as it comes in rolls, which are usually 42 ins., breaking the line where it is necessary.

30. Title should show: 1st, name of railroad; 2d, name of division or branch; 3d, name of points between which survey is made; 4th, show station and mile post of beginning and ending of survey; 5th, dates of beginning and ending of survey; 6th, scale of map in feet per inch; 7th, in all cases show true course and magnetic variation on map; 8th, show name of Locating Engineer, Transitman, Levelman, and initial of Draftsman.

31. Show magnetic variations every 25 or 30 miles on east and west lines.

32. Show ties to boundaries of claims, homesteads, etc.

33. Where the country has not been surveyed, observations for latitude should be taken every 25 or 30 miles to locate the line on general maps, and longitude calculated from some known point on the survey if possible.

34 Maps should show the general topographical features of the country by etching for two or three miles on each side of the line, giving elevations if possible of controlling points, hills lakes etc.

35. Show character of soil and timber if any on each mile.

36. Show mile post from beginning of survey with its station number each mile.

37. In making tracings, use only colors that will blue print. Usually everything can be shown in black excepting the center line, which can best be shown in vermillion water color, and the contour lines should be shown in burnt sienna water color. The outline of water can be shown in black and colored with blue pencil, and care should be taken to show the direction of flow of water.

38. Show all courses, and station numbers at angle points.

39. Send in tracings of map on the 15th and last of each month, showing work done to date, or at such stated times as the Engineer of Surveys may indicate.

40. When a topographer is furnished, the map should show contour lines at intervals of 25 or 50 ft., according to the character of the country, and at least one-fourth of a mile on each side of the line.

PROFILES.

41. Profiles should generally be 2,000 ft. to the inch horizontal and 100 ft. to the inch vertical scale.

42. Show classifications of material in cuts.

43. Show grade line that it is possible to get on location, giving elevation of change points and rate of grades.

44. Show elevation of water in lakes and rivers when running close to same.

45. Show mile posts from beginning of survey with their station numbers.

46. Elevations should start from some known elevation above mean tide, if possible. If not possible, take barometer reading which should be set at some known elevation before starting from railroad or sea level, and show an equation when connecting with correct survey.

47. Title same as map.

48. Show depth of water in crossing lakes or rivers, and best available information as to flood height and conditions.

49. Show length and number of spans required for river crossings and at important crossings make ordinary scale profile of crossing above or below the regular profile.

50. Profiles sent in should invariably be on half width of tracing profile paper, viz., 10 ins., and should show snow slides and magnitude of same.

GENERAL.

51. Location Engineers should occasionally report on the efficiency of their equipment, making such suggestions as they may think best to make it more desirable or economical.

52. The plans and possible location of route, etc., are to be carefully guarded by engineers and all employes of this company, and the giving out of information of this nature will be treated as a serious breach of trust and followed by instant dismissal.

53. To obtain the Azimuth from direct observations of the sun:

(L) Latitude	42° 14'	Arithmetical complement log cos	0.130096
(A) Altitude	30° 43'	Arithmetical complement log cos	0.063422
(P) Polar Dist	85° 29'	Arithmetical.	
	2)158° 26'		
S	79° 13' log cos		9.272061
S − P	6° 16' log cos		9.997397
			2)19.466879
			9.733440
		Which is log. cos of	57° 14'
			2
		True Azimuth	114° 28'
(L) Latitude	42° 16½'	Arithmetical complement log cos	0.130819
(A) Altitude	37° 16½'	Arithmetical complement log cos	0.099229
(P) Polar dist	71° 47'		
	2)150° 80'		
S	75° 40' log cos		9.393685
S − P	3° 53' log cos		9.999002
			2)19.622735
			9.811367
		Which is log. cos of	49° 38'
			2
		True Azimuth	99° 16'

(Note.) The polar distance is obtained by adding the sun's apparent declination, as obtained from the Nautical Almanac to 90° when the sun is south of the equator and subtracting the same when the sun is north of the equator.

The latitude is similarly computed from an altitude observation of the sun at noon, corrected for refraction.

The Altitude (A) is also to be corrected for refraction.

The refraction equals the natural cotangent of the altitude expressed in minutes. Thus, for an observed angle of elevation of 33° 41', the natural cotangent being 1.5, the corrected altitude would be 33° 41' − 1.5 = 33° 39½'.

(Note.)—The correction for refraction must always be subtracted from the observed latitude.

(Note.)—In taking out the arithmetical complement of the log. cos., subtract from 9.999999, beginning at the left and passing to the right.

(Note.)—When taking the observation from Azimuth, the sun should be at least two hours from the meridian. True Azimuth can be obtained by observation on Polaris or by equal altitude of star or the sun.

PRELIMINARY LINE.

54. The preliminary line must be run with care, after the exploration line has been run, and must be made to approximate closely to the final location, or near enough so that accurate topography can be taken to show the profile of the projected location. If the first line is not near enough, run another so as to give a strip of sufficient width of correct topography through which to project the location.

55. In cases where there are two or more possible lines, they can usually be reduced to two lines by an inspection on foot, and two lines should always be run in case of doubt.

56. The object of the preliminary survey is to serve as a base for topography.

57. Take ties to all lines and boundary lines of all kinds by angles and measure the distance to all corners.

58. Take soundings where the line crosses swamps or bodies of water.

59. Run a line a quarter of a mile distance up and down rivers on each side of the preliminary line at the place where it crosses same to locate the waterway accurately.

TOPOGRAPHY.

60. Topography should in all cases be shown by contour lines taken either by slopes or hand level. A very satisfactory method is to plot the line on sheets of paper, say 12 inches by 18 inches, fastened to a light board by thumb tacks, and by using the hand level and tape sketch the contours on the map in the field. The sheets should have the center line platted on them before going into the field. The sheets are added one after another as the plotting progresses, lapping one side or corner always under the preceding sheet, and giving its axis any random direction compared with the other which will best serve to keep the center line of the survey in the middle of the sheets. The sheets are pinned together with thumb tacks and two or three X marks made at the laps so that they can be replaced at any time in exactly the same position. A north and south base should then be laid down the full length of the sheet, nearly in the middle and the consecutive number of the sheet penciled on, always in the same corner. The contours taken in the field are then traced directly from the sheets onto the tracing, which has the line plotted on it accurately in the office. The notes should show the distance to each contour (taken in the field) from the center line, as per Fig. 2. When the contours are taken in topography book the same system can be followed as on the sheets, with the exception that two books will necessarily have to be used at the same time, one for the draftsman to work from and one for the topographer to use alternating same. To facilitate the work, standard topography books will be furnished by the company. Contours should be sketched in carefully between all points of measurements.

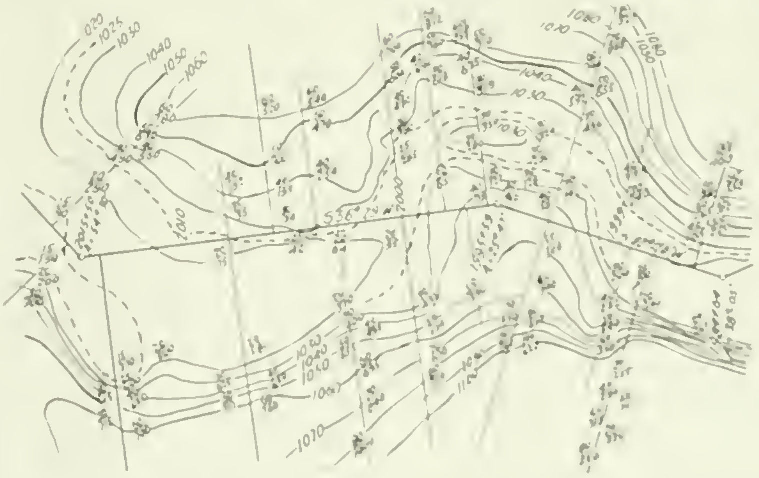


Fig. 2—Sample of Contour Map.

61. When topography is taken by slopes, which should be done only where the country is of a regular character and not broken up badly, the topographer should use a slope level, or clinometer, and a straight rod from 10 to 15 feet long, and keep the notes so as to show the slope angle whether plus or minus, and the length of each slope accurately, thus:

$$\frac{6^\circ}{210}\quad\frac{\times 10^\circ,}{180,}\quad\frac{-24^\circ}{300}, \text{ etc.}$$

Slopes should be taken every 100 feet along the center line, but it is only necessary to go out at right angles a distance of from 700 to 1,000 feet every 200 or 500 feet along the center line, according to the character of the country. The notes can be best platted on the map by use of a slope table. The object of topography, by whichever method employed, is to project a location, and no labor, time or limited expense should be spared to take it accurately, as the whole result of the survey depends on the topography. The Locating Engineer in charge of the party will be held personally responsible for results, and he, therefore, should not keep men who are not capable of doing first-class work, but should ask his superior officer for other men in case the men he has are not competent after a thorough trial and proper instructions have been given them.

MAPS.

62. Make all maps on scales of 100 to 400 feet to an inch, according to character of country, and they should conform to the Standard Map furnished. The top of the paper should be to the northward or westward, considering the general direction of the road, and the letters to be right side up when looking toward the top or lefthand side of the paper. Maps should be made on paper or tracing cloth 18 to 21 inches wide, or one-half the width of the paper or tracing cloth as it comes in rolls, which are 36 or 42 inches wide, breaking the line where it is necessary to keep the line or topography on the paper. Do not lap the breaks so as to mix up the topography. Maps should conform to the Standard Maps furnished. Where change of scale is made on map make a break on same and mark scale on each part of map.

63. The title should show:

1st. Name of railway.

2d. Name of division or branch.

3d. Name of points between which survey is made.

4th. Show station and mile post at beginning and ending of surveys, also date.

5th. All courses are true courses.

6th. Name of locating engineer, transitman, draftsman, leveler and topographer.

64. Show correct observations for magnetic variatons every 25 or 30 miles on east and west lines.

Take ties to section corners, homesteads, mineral claims, and government lines by angles and distances as often as practical.

65. When the country has not been surveyed, show the latitude of the points on the line every 30 miles at least. The longitude will be taken from some known point and calculated by the surveys.

66. Show lines of all provincial boundaries and ties to same.

67. Indicate on the map the character of the soil, timber, etc.

68. Show mile post every mile, giving the station number of same.

69. On tracings, use only colors that will print, contours in burnt sienna water color, preliminary line in light black line, projected location in heavy dotted black line or vermillion water color (black preferred). The outlines of water can be shown in black, colored by blue pencil, or a wash of blue water color, and care should be taken to show the direction of the flow of the water.

70. Show all courses, stations, and angles at angle points, station numbers at both beginning and ending of curves and at every even 500-foot point; also the course of the tangents, total angle in all curves and degree of the curve. Mile posts should be shown in the projected line, instead of on the preliminary line.

71. Contour lines should be shown by burnt sienna water color, full lines every 10 feet in elevation and dotted lines for 5-foot contours where it is necessary to show any change of slope between the 10-foot contours. Make the even 50-foot contours heavy, so as to distinguish them easily, and mark the elevation often on the contour lines. Five-foot contours, except on very easy slopes, only tend to confuse.

72. Contours should be taken at least 1,000 feet on each side of the center line of survey, or to an elevation of 100 to 150 feet above the center line.

73. Avoid showing contours split, as they can very seldom be correctly shown thus. There should be two contours to represent the top of a ridge or the bottom of a valley.

74. Show dotted contours below water level in lakes or rivers.

PROFILES.

75. Make same to conform to Standard Profiles.

76. Profiles should show the ground line as taken from the projected line on the map, as shown by the contours.

77. Show the classification of all cuts and borrow pits.

78. Each mile should have a summary of the quantities, showing each class of material.

79. Show the alignment on the bottom of the profile (see Standard Profile).

80. The character of the timber, etc., should be shown on the top of the profile, and the character of the soil and ground on the second line.

81. Show the average slopes of the ground for each cut and fill just under the above line.

82. Show mile posts from beginning of survey with their stations.

83. Show the cubic yards in each cut and fill, with classification.

84. Show the size, length and kind of structure proposed and of all culverts at each waterway, including snowsheds.

85. Each profile should have a summary for each mile and a general summary of the quantities just under the title at the beginning.

86. The grade line should be shown in vermillion water color, with the rate of grade and elevation of change points.

87. Profiles should be made on tracing profile paper. They should be made on plate "A" paper.

88. Vertical parabolic curves should be put in at intersection of grades, using curves changing not more than 0.10 per station in sags, and not more than 02 20 per station on summits, curves to be figured by the following formula:

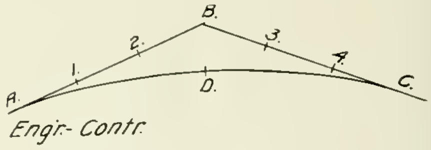
$$\frac{L}{R} = A \text{ and } \frac{O}{8R} = A$$

Where L equals length of vertical curve, which is equal to AC.

A equals algebraic sum of intersection grades.

R equals rate of change per station.

O equals middle ordinate or BD.



Fif. 3—Diagram Explaining Vertical Curve Formula.

Any other ordinate, as at 1 and 2, or 3 and 4, etc., will be to the middle ordinate O as the square of the distance $A1$ and $A2$, or $C4$ and $C3$, respectively, is the square of the distance AB or CB.

The diagram Fig. 3 will explain the above assumptions and formula:

Examples: Given two grades AB and BC intersecting at B, AB being plus 1.0% and BC being minus 0.6% grade, and the rate of change per station being 0.10, then the length of curve L equals:

$$\frac{1.0+0.6}{0.1} = 1{,}600 \text{ ft.}$$

and the middle ordinate

$$O = \frac{(1.0+0.6)}{8\times 0.1} = 3.20 \text{ ft.}$$

It simplifies matters, when practicable, to make intersection B at an even station and make the length of curve an even number of stations, making rate of change R to fit same.

LOCATION.

89. The located line should generally first be projected on the preliminary map from the topography and then run in on the ground. However, in some localities, such as along water front, with the water as a guide, the line may be successfully

located directly on the ground first and any small necessary changes can be made afterwards, when cross-sections have been taken.

90. Velocity grades, requiring speeds in excess of 30 miles per hour, must not be used, nor should such grades be laid out for speeds in excess of those obtainable under ordinary working conditions. These grades must not be used except as a temporary expedient and where they can be replaced by the actual maximum grades in permanent construction without extended changes in the already constructed line. The length of velocity grades for different speeds to be taken from a diagram which will be furnished.

91. Exercise extreme care in fixing the location for stations, water tanks, coaling chutes, etc., and in adjusting grades for same, to reduce the cost and disadvantages of train stops to the minimum.

92. Ruling grades at sidings should be compensated to facilitate the starting of trains at the rate of 0.2% per station for a distance of 3,000 feet, which should be distributed as follows: 1,200 feet on siding, 1,200 feet below siding, and 600 feet above siding.

93. Note for record the kind and quality of material to be moved. Whether rock is soft and friable or solid, and the probable method of construction which will be necessary, especially where the country is swampy or of a tundra formation.

94. The usual classification of grading will be: Earth, hardpan, loose rock, and solid rock. If cemented gravel or soft rock in place, or other distinctive material exists in considerable quantities, the fact must be reported to the engineer of surveys, in order that it may have proper classification assigned to it.

95. Trestling, unless required for waterways, should not be considered, unless the cost of embankment will exceed both the first cost of the bridges and the maintenance, assuming the life of the bridge at ten years. Temporary bridges will, of course, be considered when material for fill is not obtainable in the immediate vicinity.

96. Note that stream diversions, even when of considerable magnitude, usually prove cheaper, both in first cost and in maintenance, than bridging, particularly when the excavated material is used in embankments.

97. Compensate curves on ruling gradients at the rate of 0.04 feet per degree, and be sure that the rate of pure grade, plus curvature resistance, does not exceed the ruling grade.

98. When practical, a grade of at least 0.2 per station should be used for the drainage of cuts.

99. A rate of curvature less than 1° per 100 feet should not be used except in case where the intersection angle is less than 3°. As curves less than 300 feet long are objectionable, a rate of curvature should be used to give that length. Curves lighter than one degree should not be made longer than 300 feet, except in special cases where lighter curvature is found to be necessary to fit the country. Avoid broken back curves. Tangents of at least 500 feet should be obtained between curves in the same direction if possible.

DRAINAGE

100. Location engineers will give special attention to the determination of the necessary length of bridges and size of culverts, and should keep a notebook in which is entered an estimate of the extent and general description of the character of the area drained by each waterway, cross-sections of streams at flood heights, and any other items of importance bearing upon the question of drainage. These notes should be full and explicit, and should give the local names of creeks and and small streams, as well as the names of rivers, and should refer to the station number on survey stakes in describing the streams.

101. On all located lines detail profiles on plate "A" profile paper, scale 20 feet to an inch, should be made of ravine sections where bridges are required. This should show the center line for a greater distance than the length of the proposed bridges, and also a parallel line on each side 25 feet from the center line. It should also show high-water mark surface indications of rock, as well as grade line, with elevations of stations.

102. Thorough drainage is a maxim to be impressed on the mind, and engineers must beware of being misled in so-called rainless districts.

103. A tidal estuary may generally be narrowed considerably from the extreme water lines if stone revetments are used to protect the banks from wash. In sections where the current is sluggish, it is generally safe to encroach a little on the general width of the stream, but in rapid streams among the hills, the width that the stream has cut for itself through the soil should not be lessened, and in ravines carrying mountain torrents the openings must be left much larger than the ordinary appearance of the banks of the stream would seem to make necessary.

104. Culverts and waterways of perishable material should have ample allowance for future permanent construction.

DRAINAGE AREAS

105. Drainage areas should be measured while the location survey is in progress for the purpose of determining the size of bridge openings.

106. The areas of streams more than 12 or 15 miles long may usually be taken from maps by the topographer or [illegible], but for small streams this may be done most rapidly and with sufficient accuracy by stadia methods. (See Exploration Surveys.) However, if it will delay the progress of survey to any considerable degree this may be left for the construction engineer to determine.

107. In case of doubt as to the size of the openings, it is better to err on the side of safety by leaving openings large, especially in drift or meandering streams.

108. The topographer should take large scale sketches of all streams near crossings from which proper positions of bridges, as well as changes of channel, may be determined. He should also note when waterways can be consolidated.

109. The following formula will give the area in square feet for openings for any given area:

A=area of opening required in square feet.
M=area of watershed in square miles.
$A=127.21\sqrt[4]{M^3}$ until the area of watershed is 8 sq. miles.

Then use the following formula:

$A=214\sqrt{M}$. The former being Prof. A. N. Talbot's, and the latter Meyers' formula.

Table below is calculated for hilly country. For mountainous country add 25% and level country use 50%.

Area of water shed in sq. miles	Area of opening required in sq. ft.	Area of water shed in sq. miles	Area of opening required in sq. ft.	Area of water shed in sq. miles	Area of opening required in sq. ft.	Area of water shed in sq. miles	Area of opening required in sq. ft.
.01	4	2.2	[illegible]	28	1132	450	4540
.02	7	2.4	247	30	1172	500	4785
.03	9	2.6	260	32	1211	550	5019
.04	11	2.8	275	34	1248	600	5242
.05	13	3.0	290	36	1284	650	5456
.06	15	3.2	304	38	1319	700	5662
.07	17	3.4	[illegible]	40	[illegible]	750	5861
.08	19	3.6	[illegible]	45	1436	800	6053
.09	20	3.8	346	50	1513	850	6239
.10	22	4.0	360	55	1587	900	6426
.15	30	4.2	373	60	1658	950	6595
.20	38	4.4	387	65	1725	1000	6767
.25	45	4.6	400	70	1790	1100	7098
.30	52	4.8	412	75	1853	1200	7413
.35	58	5.0	425	80	1914	1300	7716
.40	64	5.5	457	85	1973	1400	8007
.45	70	6.0	488	90	2030	1500	8288
.50	76	6.5	518	95	2086	1600	8560
.55	81	7.0	548	100	2140	1700	8823
.60	87	7.5	577	110	2244	1800	9080
.65	92	8.0	605	120	2344	1900	9328
.70	97	8.5	624	130	2440	2000	9570
.75	102	9	642	140	2532	2200	10041
.80	108	9.5	660	150	2621	2400	10485
.85	113	10	676	160	2707	2600	10912
.90	118	11	710	170	2791	2800	11324
.95	122	12	741	180	2871	3000	11720
1.0	127	13	772	190	2949	3500	12661
1.1	137	14	801	200	[illegible]	4000	13534
1.2	146	15	829	220	3174	4500	14356
1.3	155	16	[illegible]	240	[illegible]	5000	15132
1.4	164	17	882	260	[illegible]	5500	15871
1.5	172	18	[illegible]	280	[illegible]	6000	16576
1.6	181	19	[illegible]	300	[illegible]	6500	17253
1.7	189	20	[illegible]	[illegible]	[illegible]	7000	
1.8	198	22	1004	[illegible]	[illegible]	7500	
1.9	206	24	[illegible]	[illegible]	[illegible]	8000	
2.0	214	25	[illegible]	[illegible]	[illegible]	8500	

SPIRALS

110. Spirals will be used at the ends of all curves of 2 degrees and upwards. When practical the length of spiral curve in feet will be obtained by multiplying the elevation of the outer rail in inches by velocity in miles per hour.

When spiraling for 25 miles per hour, use Talbot's table No. 10, where $a=5=1$ degree in 20 feet, and allow 50 feet between spirals. When conditions of the ground will not permit of the use of a spiral of this length, use $a=6=1$ degree in 16⅔ feet, and allow spirals to meet. This will be the minimum allowed. A. N. Talbot's book on spirals will be used as a standard field book.

The maximum degree of curvature to be used will be 12 degrees unless otherwise instructed.

111. Below is a table of standard elevations for outer rail on curves that will govern the length of spirals. All curves, unless otherwise instructed, will be elevated for 25 miles per hour.

Degree of Curve......	25 Mi. per Hour......	Degree of Curve......	25 Mi. per Hour......	Degree of Curve......	25 Mi. per Hour......
1°	7-16	5°	2 1-8	9°	3 7-8
1° 20′	9-16	5° 20′	2 5-16	9° 20′	4
1° 40′	11-16	5° 40′	2 7-16	9° 40′	4 1-8
2°	7-8	6°	2 9-16	10°	4 1-4
2° 20′	1	6° 20′	2 11-16	10° 20′	4 3-8
2° 40′	1 1-8	6° 40′	2 7-8	10° 40′	4 1-2
3°	1 1-4	7°	3	11°	4 11-16
3° 20′	1 7-16	7° 20′	3 1-8	11° 20′	4 7-8
3° 40′	1 9-16	7° 40′	3 1-4	11° 40′	5
4°	1 11-16	8°	3 3-8	12°	5 1-8
4° 20′	1 7-8	8° 20′	3 9-16	......	......
4° 40′	2	8° 40′	3 11-16	......	......

112. Locating engineers must be careful to note suitable and well-located sources of water supply for tanks, etc.

113. Stations will be uniformly 100 feet long each, and numbered consecutively. It is not necessary to set stakes at each station in all cases of preliminary lines. This is left to the discretion of the chief of the party. Mark stakes on alternative lines with distinguishing letters, as *A, B, C*, but reserve *L, M, N* for located lines.

114. Mark point of spiral *BS*, beginning of main curve *BMC*, end of main curve *E, M, C*, and end of spiral *ES*, and point of compound curve *PCC*.

115. Intersection points on location are unnecessary when much time is required to put them in. Their real use is for connecting lines run in opposite directions.

116. Put in good hubs with high witness stakes at all transit points, a record of which should be kept in the transit book. THIS IS IMPORTANT.

117. Always begin long grade lines at the summit and work down. For such service carry a slip of profile paper, say, 6 inches wide and 2 feet long. Rule the proposed grade line on it, assume a summit cut, mark the stations, and start down. When at fault, the elevation can be spotted on the profile, which will show at a glance the relation to the grade.

118. All true courses of the line must be given and an observation must be taken upon starting the survey and true course recorded in the field book as the work progresses. An additional observation should be taken for the correction of meridian convergency whenever the extent of the survey shall attain a departure of one-half degree of longitude.

119. To illuminate cross-hairs when observing the north star, wrap a piece of tracing cloth around the object end of the telescope so that one-half of the object glass is loosely covered. The cloth must be secured by a rubber band. Then illuminate with lantern from one side. A good night foresight may be a suitable X marked on tracing cloth tacked over a box with a candle or lantern back of it.

120. Check all change angles by reversing and with needle reading.

121. In order to secure accuracy of alignment upon the straight lines, the transitman must take double sights when establishing instrument points, reversing the telescope to correct errors of adjustment.

122. In running curves, a tangential angle of 15 degrees from one point should rarely be exceeded; 20 degrees is to be considered the maximum.

LEVELING.

123. Levels on preliminary lines, where speed is an object, and the progress of the level party limits that of the entire party, may be run with a self-reading rod without target. For checks on turning points the rodman will invert the rod. The sum of the direct and reverse reading will be equal to the length of the rod.

124. Levels on location lines will generally be run with the Philadelphia rod with target, and the rodman must carry a level book, in which he records all turning points and benches, calculating the elevation of same, and also each height of instrument, checking with the leveler each time they pass each other.

125. The level rod on turning points and benches should be read to hundredths, and on ordinary lines to the nearest tenth.

126. On all turning points and benches, the greatest care must be taken to get the vertical rod reading by using a rod level, by balancing the rod, or by waving it when there is a wind.

127. Always establish substantial and permanent benches at the initial point of survey and at 2,000 feet intervals along the line, where they will be protected. In all cases, where practical, place bench on a solid rock, tree or stump, so that it will not be disturbed by the construction forces. If no stone, tree or stump is available, drive a good solid hub. Use mean tide datum when same can be obtained, and if one has to be assumed, ascertain its relation with the standard datum at the first opportunity and make proper note of the same.

128. The elevation of benches must be plainly marked upon a blazed spot upon trees, or upon a stout guard stake driven a foot from the bench mark.

129. All bench marks must be plainly described in the level notes, and both elevation and description noted on profile as they are established, and at the back of each level book a few blank pages should be left, on which should be entered a list of the benches upon that part of the line covered by the book, with their description.

130. The leveler will note the surface elevations in the beds of small streams at suitable intervals, the high-water marks of streams parallel to the line, but locating engineer should describe the condition of stream as regards ice and driftwood, kinds of bottom, etc.

131. The leveler will keep a note of occasional pegs, describing them with reference to the nearest stake so that the levels may be taken up speedily in case of a revision of the line.

132. All level notes must be checked at the end of each day's work by adding the back sights and fore sights and ascertaining the difference. Doubtful sections must be re-run.

133. Six hundred feet each way should be regarded as the maximum sweep of the level.

134. The leveler may use a hand level to peg into narrow hollows, or over heights which cannot be turned with the instrument. He must record his work and make up his profile daily.

TOPOGRAPHY.

135. On preliminary, whenever a help to location, and on location, whenever helpful to revision, topography must be carefully taken.

136. Since the amount of topography actually needed and used is small; no attempt should be made to cover the whole map with accurate topography. On the other hand, accurate contour lines for a reasonable distance on each side of a line are a great aid in projecting location, and at critical points must not be omitted. Enough sketched topography shown in dotted lines should be used to show that no other and better alignment might have been adopted.

37. The topography should be carefully taken by actual measurements to important points, and must be correctly shown by contour lines where the surface of the ground is intersected by horizontal planes at each even 10 feet of height, taken on the datum of the survey. Every fifth contour should be heavy. The elevation of each contour should be marked at frequent intervals. Five-foot contours should be shown dotted when the slope changes abruptly near the center line.

138. Topography is neither to be used as a safeguard against the larger errors of location, nor for giving the last degree of perfection to the details of alignment. The finishing work must be done on the ground.

LAND LINES.

139. Connect with all sub-division lines of the United States Land Surveys. These measurements should include the angle made by the railroad line with each homestead, mineral claim, townsite or other land line. The station of the railroad survey at which the line intersects any land line, homestead, or mineral claim must be given. A correct plat, properly printed, must be drawn in the topography book, showing plainly the above information.

140. When the line is located through villages or towns, take all measurements necessary to tie the center line to the plat.

141. All the above land connections should be complete on final lines. On pre-

liminary lines as much should be taken as can conveniently be outlined.

142. In starting surveys, always obtain true meridian, either from Polaris or from direct observation of the sun (see Paragraph No. 53), or equal altitudes of a planet, and monument same for reference.

143. On definitely located lines at intervals of one mile from the origin of survey, the center line should be monumented with two stakes at least four inches square on top, set at right angles to center line, not less than 25 feet, and usually 50 feet, as a standard from said center line, and out of the way of being disturbed by construction forces.

MAPS

144. Every map and tracing should have a title, giving the corporate name of the railroad company, the name and date of the survey, and the name of the locating engineer, transitman, leveler, topographer, and the initials of the draftsman.

The scale should be distinctly marked, and also the true magnetic meridian. When the latter is not otherwise known, draw it from the magnetic variation.

145. Maps and profiles should follow the same general direction, south and west to the left, and north and east to the right, considering the general direction of the road.

146. Preliminary maps should, in general, be on a scale of from 100 to 400 feet to the inch, unless otherwise ordered by the engineer of surveys. General maps comparing preliminaries must be drawn to a scale of 2,000 feet to the inch, and should be accompanied by a condensed profile on plate "A" tracing profile paper, horizontal scale two miles to the inch and vertical scale 100 feet to the inch.

147. Location maps should be drawn to a scale of 100 to 400 feet to the inch, unless otherwise instructed by the engineer of surveys. To avoid cumulative errors in platting, plat preliminary maps from meridian carried through from beginning with protractor. Located lines should be platted from latitudes and departures. A map of scale 2,000 feet to the inch must be made to accompany each full scale map sent in.

148. Enough topography should be put on location maps to give a true conception of the ground in the vicinity of the line. Take numerous ties to preliminary lines, so that it will be possible to trace all topography taken on preliminary lines to fill out the map so as to show the country fully within a distance of 1,000 feet from the center line.

149. Maps must conform to Standard Maps and must show the station and plus of each BS, BMC, EMC and ES. Central angles of curves and spiral angles, and true bearings of tangents. Designate spiral by value of *a*.

Show the mile posts from the initial point and the full stations at suitable intervals.

Show the position and name of any settlement, cabins, or houses near the line, and direction with arrows of all streams.

Show property lines, names and owners, political boundaries and roads, homesteads, mineral claims, tide lands, townsites, etc.

On location maps show the width of right of way required with the extra amount necessary for stations, sidetracks, Y's, borrow pits, waste banks, etc. The usual width of right of way will be 100 feet.

Details of junctions, stations, etc., should be shown on a larger scale, and if convenient, may be put on one side of the general map.

150. The use of colored ink is discouraged. It should be the object of the draftsman to make his map clear without this aid, and so that it will not lose its utility by being traced and blueprinted.

151. Tracings of maps must be sent to the office of the engineer of surveys as the same are completed in 10-mile sections. They must be accompanied by a copy of the alignment notes from which made. Locating engineer must make sure that they are correct before leaving their hands. They should invariably be made on the unglazed side of the paper.

152. All maps, plats and profiles should have nine inches' clear at each end, so that handling will not make the markings indistinct.

PROFILES.

153. Profiles must conform to Standard Profiles to be furnished, and must be made on tracing profile paper.

154. The lines will be divided into sections of one mile in length. Each section should be separately estimated.

155. This will not prevent the removal of material required for the roadbed, or structures from one section to another, whenever in the opinion of the engineer this may be expedient.

156. Profiles should break, where practicable, in the same section as the map, and have a corresponding title.

They should be made in the same direction as the maps, west and south being to the lefthand and north and east to the righthand, considering the general direction of the road.

157. The engineer should try to put all information in regard to the line, such as camping places, pumps, water supply for tanks, etc., on the profile so it is there in permanent and accessible form.

158. Profiles must show under the base line the BS, BMC, EMC and ES, grade points, all angles between connecting tangents, spiral angles with direction (right or left), degree of curve and true bearing of tangents. Designate every curve angle as I, spiral angles as Δ and total intersection angle as I. Give value of "a" in spiral curves.

Show the surface of the ground, grade line, rate of grade and elevation of every angle in the grade in figures directly below the grade line. Also give elevation and station of grade intersections on the first upper line of profile and show character of timber, vegetation, etc. On the second line show character of ground and soil. On the third line show lateral slope of ground at each station.

Show the location, description and elevation of all benches.

Show the position of mile posts, and the elevation of every 100-foot line and at intervals where the ground changes between stakes.

If the profile is made to an assumed datum a note to that effect should be made, adding the following: "To reduce to true elevation above the sea add ..... feet," leaving out the figures if not known, but always adding the note.

159. The elevation for both high and low water of all streams crossed, and at intervals of all streams with which the line runs closely parallel should be given.

160. Give the estimated structures (including bridges, buildings, culverts, etc.) required at all points where they are known, with notations of all special work proposed, such as changing channels of water courses, protection of embankments, slidesheds, snowsheds, etc.

161. Give the estimated or actual quantities in each cut or fill, with classification, the yards and direction of overhaul, and a summary by sections, as follows:

SECTION NO.

Clearing	Squares (100 ft. sq.)
Grubbing	Stations
Earth excavation ...	Cu. yds.
Loose rock excav. ...	Cu. yds.
Solid rock excav. ...	Cu. yds.
Hardpan excav. ...	Cu. yds.
Excavation wasted ...	Cu. yds.
Embankm't. borrowed	Cu. yds.
Riprap	Cu. yds.
Culverts	lin. ft. each size
Pile bridges	lin. ft. each size
Trestle bridges, frame	ft. B. M.
Snowsheds ...	lin. ft.
Diversion dikes	lin. ft.

Any unusual work, such as viaducts, trusses, girders, arches, stone culverts, etc.

Excavation should include all extra excavation, such as ditches, channels for highway crossings, snowsheds, etc.

Show all points of water supply, names of settlements and of property, and other boundary lines as far as known.

162. All breaks in stationing are to be indicated as follows:

When the difference is less than one station the profile will be made continuously and the discrepancy indicated by two heavy lines and the words "long" or "short" station, with its length. (When the error is for more than one station, if there is a gap in the stationing, an equal space will be left on the profile. When there is a duplication of stations the profile will be broken and lapped over so as to leave the stations at the bottom of the profile in all cases uniform and continuous. Every ten stations must be marked in tens and every fifty stations marked in full at the end of each section of profile so affected. A summary of short stations, stations duplicated or omitted, also total distance added or subtracted, shall be made.

163. At each end, and on the back of the profile, a title shall be made showing the chraacter of the survey, whether preliminary or final, the corporate name of the railroad company for which the survey is made, the opening and closing station numbers, also the miles indicated by same, the proposed beginning and ending points of the survey, the name of the locating engineer, transitman, leveler, topographer, and initials of draftsman. The locating engineer must see that this title is marked in ink upon all profiles sent from his office or camp.

164. Tracings shall be made in 10-mile sections, unless otherwise instructed, from the original profile, and sent to the engineer of surveys, from which the necessary blue prints will be made for construction purposes.

NOTES.

165. The notebooks to be used will be transit books, level book, topography book, and diary.

166. A title must be written on the fly leaf of each book, giving the name of the locating engineer, transitman, topographer, as the case may be, with a brief statement of what the book is used for, similar in form to the following:

ALASKA CENTRAL RAILWAY CO.
Location Surveys. Party No. 3.
Transit Book No. 1.
Beginning at Stn. ....
Ending at Stn. ....
FRANK BARTLETT, Locating Eng.
1161 S. 6th St., Tacoma, Wash.
DOUGLAS KYLE, Transitman.
1528 N. Oak St., Tacoma, Wash.

The title must be placed on fly leaf at the beginning of book, and in no case on the outside of cover, which will be left unmarked, excepting possibly the number of the book, which may be placed, if desired for the convenience of the locating engineer, in the upper righthand corner of the cover.

167. Each leaf must be numbered consecutively from the beginning.

168. The beginning and ending of each day's work should be dated, and character of work noted.

169. Carefully index on first page of book each separate piece of work, noting abandoned lines, etc.

170. Indexing and numbering of pages must be carried on promptly as the work progresses in all cases, and not left until the survey is finished.

171. Field notes must not be kept on paper or in memorandum books and transferred later into the proper books, but must be entered in the proper book in the field, as only original notes are permissible.

172. In memorandum books will be entered all cross-section notes of unusually steep or rugged ground, where ordinary methods of determining quantities cannot be used. Notes of foundations of structures, character of timber, agricultural notes, traffic possibilities, and any information that cannot be recorded in any of the other books, including ice movements in bays and rivers, etc., shall also be entered in memorandum books.

173. The diary should show for each day the character of weather and what work the party was engaged on, serious delays and cause of same—in short, a general history of the work.

174. In case of line revisions or abandoned lines, notes in no case shall be erased, but shall be crossed out with diagonal pencil lines, and the word "abandoned" written across the page, noting book and page where notes of revision are to be found.

175. The notes of each day's work shall be worked up each evening and not left to accumulate.

ESTIMATE OF QUANTITIES.

176. Estimates must be kept up with the location and recorded on the profiles by sections.

177. Precaution must be taken to include everything necessary to complete the work ready for the track.

178. Estimates of quantities may be made from suitable tables or diagrams, and should include the effect of side slopes on same. Tables of quantities will be furnished by the engineer of surveys.

179. Embankments will be 14 feet wide at sub-grade, except when 16 feet and over in height, when they will be 16 feet wide at sub-grade. All earth embankments are to have a side slope of 1½ to 1. Embankments made from solid rock cuts may be made with side slope of 1¼ to 1.

180. Excavations in earth will be made 14 feet wide at sub-grade with 1 to 1 side slopes, except when, in the judgment of the engineer, it will be necessary to flatten same on account of soft material.

181. Excavations in solid rock will be made 14 feet wide at sub-grade, with ¼ to 1 side slopes, or flatter, as in the judgment of the egineer may be necessary in order to take care of loose or dangerous material.

Where water is to be carried in ditches, rock cuts may be widened on the ditch side, as the judgment of the engineer may show it necessary.

182. Excavations in hardpan, soft, friable rock, or loose rock will be made 14 feet wide at sub-grade, with side slopes from ½ to 1 to 1 to 1, according to the character of the material.

183. Prices to be used for comparative estimates of lines are given in the accompanying table.

ECONOMIC ESTIMATES.

184. The following general instructions are to be followed in estimating the cost of eliminating distances, curvature, rise and fall, etc.:

Use five round trips per day as the basis of calculation. Where daily trains are used, it means one trip each way per day.

Distances:

Class A—One-half mile or less will be estimated to cost $7,000 per mile daily train per year, or $1.33 per foot, which is the amount that can be spent economically to save one foot of distance per daily train.

Class B—From one-half to five miles will be estimated to cost $10,000 per mile, which is the amount that can be economically spent to save one mile of distance every daily train.

Class C—From 5 to 100 miles will be estimated to cost $12,900 per mile, which is the amount that can be spent economically to save one mile of distance per daily train.

185. Curvature will be estimated at $9.90 per degree, which is the amount that can be economically spent to save one degree of curvature per daily train.

186. Rise and Fall:

Class A includes rise and fall of minor gradients, where the rise is small or the grade so light that a train approaching the top of a hill at a speed of 15 miles per hour will not exceed a maximum speed of 30 miles per hour at the bottom of sag of grade if the steam is not shut off, which will include all sags 25 feet deep, and all grades of less than 0.6%, however long. It will be estimated that it will be economical to spend $9 to save one vertical foot per daily train.

Class B is equivalent to Class A, excepting that with steam shut off at top of grade the train coasting will not exceed the maximum speed of 30 miles per hour. This class of minor grades will be estimated that it will be economical to spend $28 to save one vertical foot. On ruling grades it will be estimated that it is economical to spend $37 to save one vertical foot. Class B is all rise and fall on grades over 0.6% and of length shown in table below to acquire the maximum speed of 30 miles per hour:

Gradient	0.6	0.7	0.8	0.9	1.00	1.25	1.50	2.00
Stations	170	100	73	57	48	33	26	15
Total drop...	102	70	58	51	48	41	38	30

Class C is rise and fall on grades that require the use of sand and brakes when steam is shut off to avoid velocities over the 30-mile maximum, and includes grades of 0.6% and over that are longer than the distances given in the preceding table to acquire the speed of 30 miles per hour. This class of rise and fall on minor grades will be estimated that it is economical to spend $68 per foot to save one vertical foot of rise and fall per daily train, and on ruling grades $75 per foot per daily train.

187. Pusher grades will be assumed as

Earth excavation	[illegible] per cu yd
Loose rock excavation	$1.00 per cu yd
Hard pan excavation	[illegible] per cu yd
Solid rock excavation	$1.50 per cu yd
Overhaul, [illegible] ft to [illegible] ft	1½c per 100 ft
Pile bridges 20 ft high and under	$5.00 per lin ft
Pile bridges over 20 ft high, add to above corresponding additional price	$[illegible] per M ft B M
Trestle bridges	$[illegible] per M ft B M
Timber in culverts, hewn or sawn	
Timber in foundations for breakwaters, etc.	[illegible] per lin ft
Clearing	$17.[illegible] per [illegible]
Grubbing	$2.00 per stn
Rip-rap	$1.[illegible] per cu yd
Hand laid slope wall	$2.[illegible] per cu yd
Timber in foundations and [illegible]	$2[illegible] per M ft B M
Excavation in foundations (dry)	[illegible] per cu yd
Excavation in foundations (wet)	$[illegible].00 per cu yd
Rock filling in cribs	$1.[illegible] per cu yd
Track and ballast complete	$8,[illegible].00 per mile
Howe truss bridges, [illegible] ft spans	$28.00 per lin ft
Howe truss bridges 1[illegible] ft spans	$1[illegible].00 per lin ft
Howe truss bridges 150 ft spans	$18.00 per lin ft
Tunnels, solid rock	$70.00 per lin ft
Tunnel lining, timber	$20.00 per lin ft
Combination bridges 175 ft span	$75.00 per lin ft
Snow sheds	$65.00 per lin ft
Log culverts 2 ft x 2 ft	$1.[illegible] per lin ft
Log culverts 3 ft x 4 ft	$2.50 per lin ft
Log culverts 4 ft x 4 ft	$2.50 per lin ft
Log culverts 4 ft x 6 ft	$3.00 per lin ft.

costing 50c per train mile, or $1 per mile of incline, and $365 per mile of incline per year, capitalized at 5% equals $7,300, which is the amount that can economically be spent to save one mile of incline. The number of miles which represent the difference between the miles actually run and 100 miles will cost one third of 50c, which equals 16⅔c. Then, to get the cost of operating the incline per day per daily train, multiply the miles actually run by 50c and add the difference in mileage, multiplying by 16⅔c, and the sum will be the answer. Then, the above daily cost, multiplied by 365 days, will give the yearly cost of operating the incline. Capitalize at 5% and get the amount that can be economically spent to eliminate the pusher grade.

188. To calculate the value of reducing any grade to a lighter grade to handle the same traffic, the cost per train mile will be estimated at 65c.

The above values are calculated on the assumption that the cost of operating an average train mile is $1.50.

The Importance of a Modern Expansion Bolt in Construction Work of Today.

BY H. S. SKINNER

While many, who have taken the time to look into them, are now more or less familiar with the time and labor saving qualities of a modern expansion bolt, there are easily as many more who are still unfamiliar with them. Concrete being used so extensively for building purposes, has emphasized the need for expansion bolts and added new uses for them.

Expansion bolts in their many styles and sizes are used wherever there are "things to fasten" to brick, stone, marble, concrete, tile or slate. They are made in every conceivable size, from ⅛ to 2 ins. diameter for use variously with wood screws, machine screws, lag screws and machine bolts. The cut here shown illustrates the Standard Star Expansion bolt. Attention is invited to the simple working principle and quick, easy application involved.

The shield (Fig. 2) consists of but two parts which, when held together as shown, present an interior threaded to take the ordinary coach or lag screw or bolt. To use: Drill hole, insert expansion shield (Fig. 2), put screw (Fig. 1) through material to be fastened into inserted expansion shield (Fig. 2), then turn tight and one has the positive inner end expansion shown by Fig. 3. The inner end expansion insures against chipping or defacing outer surface matter, and results in an anchor more permanent than otherwise. The shields are made of malleable iron, but they may be had in lead composition metal in sizes from 5/32 in. up to ½ in.

Identically the same simple principle of expansion characterizes the Star screw anchors, which are made in one piece of soft lead composition to fit all wood screws from a No. 7 to a No. 24 inclusive. These anchors are especially adapted for fine work in tile, brick, marble, slate, etc., and there are greatly in favor for general use by the plumbing and electrical trades.

Every one should know about machine expansion bolts, which work on a somewhat different principle and which for many special purposes are preferred to the other and more popular styles above described. Machine expansion bolts are of two kinds, single wedge and double wedge. Either will fit any standard machine bolt or screw from 3/16 in. to 2 ins. diameters, any length. The single wedge produces an inside lateral expansion rather similar in effect to the styles above shown, but operating on the principle of an engaging wedge shaped nut, which passes up thread of bolt and is thus drawn outward toward surface matter, operating as it does to spread inner sides of shield against sides of hole.

The double wedge also has the same inside engaging wedge shaped nut, but in addition there is a similar wedge shaped unthreaded collar on outer end of shield over which sides of shield force themselves outward producing a horizontal expansion.

Both of these two types, together with many other time and labor saving specialties, such as toggle bolts for fastenings to tile, terra cotta, hollow brick or metal lathing, cable dogs for supporting conduits and cable, and Star drills for brick and stone are manufactured by the Star Expansion Bolt Company, of Bayonne, N. J.

LETTERS TO THE EDITOR.

The Practicability of License Laws for Engineers.

Sirs: Your articles and editorials from time to time in regard to the various attempts in different states to enact laws requiring the licensing of engineers have been read with much interest by me.

I agree that there should be some sort of legislation to regulate engineering practice, but like you, think this could be more satisfactorily attained by a board to pass on all plans for work of any magnitude, than by licensing the engineers who prepare these plans.

The engineer who can really do the work needs no license; his work speaks for him. An examination will not prevent a rascal from obtaining a license, neither will a license prevent an error which any competent man is apt to make, but which might be detected by a board of review.

The writer does not believe that there are any two engineers in the country who

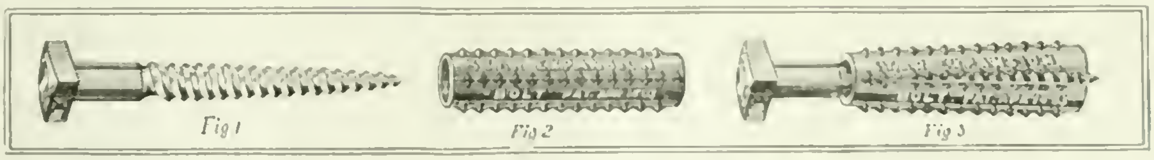


Fig 1
Fig 2
Fig 3

Star Expansion Bolt.

The first progress report on the proposed Hudson Bay Ry. has been made to the Canadian Government by J. Armstrong, the engineer in charge. Complete surveys of 320 miles out of a possible 465 are reported, while the exploration report covers 400 miles. The present estimate is that the line will cost from $8,000,000 to $11,000,000, according to the outlet port chosen. This estimate is based on a line whose controlling gradient will be a 0.4 grade for east or northbound traffic and 0.6 for southbound traffic. It calls for wooden culverts and trestles and 65-lb. steel.

Mexico produced 5.2 per cent of the world's copper in 1908, as against 9.4 per cent in 1907.

could be measured by the same standard. An engineer has to specialize his work, and if one will but think for a minute, how many branches of engineering are there? Each engineer would require a different license.

If our present civil and criminal laws are not sufficient to prevent rascality in engineering, how about other professions or trades; how about the man who shovels concrete? License him too? Then, how about interstate work? Will the engineer have to obtain a license in every state in which he works? The question of licensing engineers, I think, is too complicated to permit of ready solution.

I am glad that Engineering-Contracting has taken the stand that it has and believe with it that if we must have regulations, regulate the work and not the man.

Yours truly,

Chas. F. Burrell.

Albion, Ill., April 5, 1909.

A Suggestion for Regulating the Practice of Engineering.

Sirs:—I have noted from time to time articles dealing with the subject of examining and licensing engineers. In the issue of March 31 I note an article dealing with the law that was introduced in our legislature this winter providing for such examination and licensing, and also your editorial comments on the article.

In the main I am inclined to agree with the position you have taken on this subject so far as the question of protecting the profession against incompetents and rascals, but I can hardly agree with your proposal of creating a board of review or supervision of engineer's plans for public works. It appears to me that such a board would of necessity be too cumbersome and expensive. In fact, I am sure that the provisions of such a law would be evaded in many instances because of the attendant expense. It would cost as much to bring a member of such board across the state to examine and approve the plans of a $500 culvert as it would to do the same for a $20,000 bridge. And yet the culvert, if poorly constructed, might be as great a menace to the public as would the bridge.

I believe that it should be the law that no person should be deemed eligible to hold any engineering position in which he would be called upon to plan or construct any public engineering work of importance, without having first successfully passed an examination before a board of competent engineers. What I mean is that road engineers, county engineers, and municipal engineers should be chosen from those who hold a legal license. Further than this I would not go.

We are not allowed to select any person for the office of prosecuting attorney who has not been admitted to practice at the bar, but that does not prevent any one from conducting a case in court if he can find a client who is willing to trust a case in his hands. No person who does not hold a certificate as a qualified school teacher can hold the office of superintendent of public instruction, either in the city, the county or the state, but that does not prevent any one from conducting a private school if he can find the pupils.

The same policy should in my opinion apply to the profession of engineering. In order to hold a public office calling for engineering ability, the salary of which is paid in whole or in part out of the public funds, and the duties of which are of a public nature, one should, in my opinion, be required to submit to an examination before a qualified board of examiners. This would not prevent any person from practicing the profession of engineer or surveyor if he could find clients, but in actual practice it would weed out the incompetents as rapidly as would a more sweeping law. The qualifications of the public officials would set the standard, and all who could not measure up to it would be starved out. The board of review would be a valuable adjunct to such a system.

Provision could, and should, be made for the submission, under certain limitations, of all plans, specifications, supervisions or approvals of the local engineer to the same board in which the power of examination is vested, for final decision. All acts of whatever nature affecting his duties as a public official should in like manner be subject to their examination upon petition or appeal, and they should have the power to suspend or revoke his license for cause.

Under such a system all of the essential features of the proposed board of review would be retained, and at the same time the cumbersomeness and expensiveness, with the consequent tendency to evade it, would be eliminated. It is a fact that the public, while desirous of protection in theory, does not desire a system of protection that limits the right of private choice. It is quite probable that a law that would protect the public from incompetents and rascals would meet with very general approval; but it is doubtful if a law that would prevent a man from employing some loud-mouthed egoist to make a survey of his farm, or to plan the erection of his power plant, would meet with as unanimous consent. The American people still like to be humbugged too well.

Yours truly,

J. E. Tupper.

Pomeroy, Wash., April 8, 1909.

Personals.

James M. Brown, a former railroad contractor, died March 19 at his home in Ogdensburg, N. Y., aged 81 years. Mr. Brown had contracts for building sections of the old Ogdensburg & Lake Champlain R. R., now a division of the Rutland road, and for many years was superintendent of bridge construction for the company. He then went South and was a prominent factor in building railroads and bridges in Georgia and other states.

Andrew Rosewater, City Engineer of Omaha, Neb., died suddenly last week, aged 61 years. Mr. Rosewater had been engaged in engineering work since 1864, his first position being with the Union Pacific Ry. Co. He had an extensive consulting practice in sewerage and water-works construction and in pavement work. He first served as City Engineer of Omaha from 1870-5. He was again appointed City Engineer in 1881, serving until 1887. His final appointment dates from 1897.

Jasper R. Rand, vice-president and director of the Ingersoll-Rand Co., died of pneumonia in Salt Lake City on March 30th. Mr. Rand was the son of Jasper Raymond Rand, one of the founders of the Rand Drill Co., and was born in Montclair, N. J., Sept. 3, 1874. He was graduated from Cornell University in 1898 with the degree of Mechanical Engineer, and served in Porto Rico in the Spanish-American war as a member of the 1st New York Volunteer Engineers. During 1899-1900 he was president of the Imperial Engine Co., at Painted Post, N. Y., leaving that position to take the presidency of the Rand Drill Co., which he held until 1905. In that year he was elected vice-president and director of the Ingersoll-Rand Co., which was his chief interest until the last. Mr. Rand was a member of Alpha Delta Phi fraternity, of the Spanish War Veterans, of the American Institute of Mining Engineers, of the American Society of Mechanical Engineers, of the Engineers' Club, of the Cornell Club and of the Alpha Delta Phi Club of New York.

Catalogs Worth Having.

Engineers and contractors should have on file the latest catalogs of machines, tools and supplies that they use. In sending for catalogs reviewed or advertised in this paper, you will confer a favor on us if you will write direct to the advertisers and state that you saw the catalog mentioned in Engineering-Contracting. If you are in the market for tools, machinery or supplies, tell us and we will notify promptly the leading manufacturers.

No. 1184. **Sidewalk Form Holders.**—Concrete Construction Co., Houghton, Mich.

An excellent descriptive catalog relating to this company's new adjustable steel form holder and cross form for cement walk construction. The device is an interesting one and has a good record of successful work. Cement walk contractors should secure this pamphlet.

No. 1185. **The Barrett Specifications.**—Barrett Manufacturing Co., New York and Chicago.

An 8-page pamphlet showing some handsome views of large textile mills at Lowell, Mass., whose roofs were laid according to Barrett specifications. A description of the roofing is given and the Specifications are printed in full.

No. 1186. **Street Scrapers.**—W. M. Toy & Co., 435 East North St., Sidney, O.

A circular illustrating and describing the street scraper made by the company named. This scraper runs on wheels and is dumped without lifting. Superintendents of street cleaning will be interested.

No. 1187. **Polygon Mixer.**—Waterloo Cement Machinery Co., Waterloo, Iowa.

A 23-page pamphlet illustrating and describing the Polygon Mixer which, it is claimed will mix mortar or any coarse or fine, wet or dry mixture equally well. This mixing is done by the shape of the drum and in batch charges.

No. 1188. **Cement Sidewalks.**—United Kansas Portland Cement Co., Kansas City, Mo.

This pamphlet gives 8 pages of instructions and directions for cement sidewalk construction which will prove highly useful. The full specifications for cement walks adopted by the National Association of Cement Users are given.

No. 1189. **Kent Mixers.**—The Kent Machine Co., 338 N. Water St., Kent, Ohio.

The mixer described in this 24-page pamphlet is a continuous, automatic-measuring mixer, in which the entire process—measuring, dry mixing, wetting, wet mixing and discharging is automatic, mechanical and continuous, thus doing away with hand labor entirely, except what is necessary to get the materials into the hoppers. The measuring device will, it is claimed, handle wet sand and gravel perfectly.

No. 1190. **Interurban Railways.**—Allis-Chalmers Co., Milwaukee, Wis.

This 16-page pamphlet contains well illustrated descriptions of the Winona Interurban Ry., and of the new line of the Indianapolis, Crawfordsville & Western Traction System, both located in Indiana.

ENGINEERING-CONTRACTING

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Announcement of a 35 Per Cent Increase in the Reading Matter of Engineering-Contracting.

The readers of this journal have undoubtedly noticed the marked increase in the amount of advertising that the journal is carrying. [illegible] we are increasing the amount of reading matter to keep pace with the increased number of advertising pages. Therefore we are adding 35 per cent to the number of words printed in the pages devoted to articles on engineering and contracting subjects.

To effect this increase we are adding two pages a week, and are using a type that gives a much larger number of words to the page (namely an 8-point solid, except on the editorial page), instead of an 8-point leaded. Instead of 7 lines to the inch this gives 9 lines to the inch. Such journals as the "Saturday Evening Post" use the 8-point solid type very extensively. It is not trying to the eyes, and is, in fact, far more easily read than the type used in the ordinary daily journal.

Should our advertising growth continue at the present rate, we shall be able to add at least 50 per cent more reading pages before the close of the current year, and at the same time increase our editorial staff correspondingly.

Again we thank our readers for their kindly consideration in mentioning this journal when writing to advertisers for catalogs, prices, or other information, and again we repeat that such consideration on the part of our readers will be rewarded by a larger amount and better quality of reading matter and news.

Are "Cost Data Merely Approximations Suitable for Rough Estimates"?

In a brief review of Arthur's "Building Estimator," the following statement appears in "Engineering News" of April 15:

> "Bearing in mind the usual restrictions of books on cost data—that they are merely approximations suitable for rough estimates and in no wise accurate for any specific case though they may be very close to an average—this fifth edition should prove of considerable value."

So far does our contemporary miss the mark in its aim at an understanding of the value of cost data that a suggestion or two may serve to induce it to readjust its sights and fire at the target again.

Cost data, according to the News' conception, are "mere approximations," "averages," and "in no wise accurate for any specific case." While this is true of contract *prices*—and much of Arthur's book is nothing else than a table of prices—it is wholly untrue of a *unit cost*. Neither the News nor many engineers seem able to free themselves from the impression that price and cost are synonymous. Now a price is usually, though not always, based upon the supply and demand, and therefore subject to fluctuations. Contract prices, moreover, are often unbalanced, being made purposely too high on some items and correspondingly too low on others. But what is of even greater importance is the fact that a *price* is a *total* of all the elements of cost unaccompanied by anything that indicates the effect of varying conditions upon [illegible]. [illegible] For the other [illegible] the analyzed [illegible] and to illustrate by an example let us take a simple case of [illegible]. We will assume that the prices and wages are as follows, resulting in the following unit cost:

[illegible] cement delivered at $1.[illegible]	$[illegible]
[illegible] cu. yd. stone delivered at $1.[illegible]	[illegible]
[illegible] cu. yd. sand delivered at $1.[illegible]	[illegible]
[illegible] day's labor at $1.[illegible]	[illegible]
Total	$3.4[illegible]

If this unit cost is accompanied by a brief description of local conditions, method of mixing and placing, etc., who can truthfully say that it is a mere approximation "in no wise accurate for any specific case"? Were nothing but the total, $3.44, given, then there would be soundness in the contention that cost data are suitable only for rough estimates, but it is the veriest nonsense to berate all cost data because some are presented "in lumps" and therefore in an unusable form.

Even though the above example serves fairly well to illustrate our point, it is easy to select others that are longer but serve far better, especially as regards the analysis of the labor item. By an analysis of the labor item, it is possible to show not only the effect of varying wheelbarrow haul, of varying numbers or types of the materials in mixing, etc., but to show the rapidity with which the laborers worked and the judgment of the foreman in laying out his work and in selecting the tools with which it is performed. Bringing out these latter facts constitutes the most useful function of analyzed cost data.

Even a superficial study of the objects of analyzing costs should disclose to such doubters as the News that properly analyzed costs are of the greatest value in estimating, and that, in fact, no reliable estimate of projected work can ordinarily be made in any other manner.

The stigma that has attached to engineers' estimates in years past can be removed in no way except by disseminating knowledge of how to analyze costs and how to interpret such analyses.

The engineers who located and built the Northern Pacific were so far off in their original estimate that the company found its $30,000 per mile bond issue inadequate, and this inadequacy eventually put the company into a receiver's hands. What these engineers lacked was a knowledge of cost analysis and analyzed cost data.

One great project after another has thus brought discredit upon engineers until it is today almost impossible to make the public believe that any engineer's estimate is reliable. Far in the van of this caravan of engineering ignorance of cost have marched such technical periodicals as "Engineering News," blinding the trailers not behind them, but before them by deriding the worth of published cost data.

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Concrete and Reinforced Concrete Section

Note:—This section is devoted to methods and cost of constructing concrete and reinforced concrete structures. It will cover the selection, testing and proportioning of concrete materials; laboratory tests of concrete; concrete mixing, transportation and placing; fabrication and placing of reinforcement, and form construction and erection. It will also contain articles on new and interesting developments in the design of reinforced concrete.

Hints for Inspectors of Concrete Work.

IV.

Concrete is weak in tension, i. e., a strain tending to pull it apart, but it is strong in compression, i. e., a strain tending to crush it together. Reinforcement is the steel rods, bars, or netting inserted in concrete to make up for its weakness in tension. Their number, size and spacing are computed by the engineer so as exactly to supply the lacking tensile strength in the concrete member being designed. If either number, size or spacing is varied from, the strength of the concrete member is not what it was designed to be and injury results. The inspector's first duty is to see that no detail of the engineer's design of reinforcement is varied from in construction—this duty is imperative.

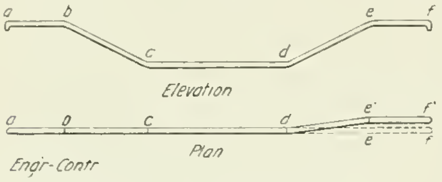


Fig. 1—Sketch Showing Common Error in Bending Reinforcing Bars.

Checking, Assorting and Storing Steel.—See that as the steel is received it is checked, assorted and stored in such a manner that it can be readily inspected, that it is reasonably protected from rust, dirt, oil, paint, etc., and that those portions needed first may be reached without disturbing the remainder.

Assemblying of Reinforcement. See that in the assemblying of the reinforcement the exact number, size, form, spacing and location of bars, stirrups, ties, spacers, etc., called for by the plans is adhered to in every member. This is a vital point and should be watched with great care and checked over just before the concrete is poured. Particular watchfulness is necessary where loose bar reinforcement is employed and the bars, etc., are placed as the concreting progresses.

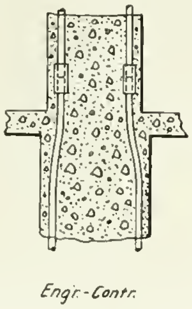


Fig. 2—Sketch Showing Bending of Column Bars at Connections.

Number of Bars.—See that the exact number of bars, stirrups, ties, etc., called for by the engineer's plans goes into every member.

Sizes of Bars.—See that the sizes of bars used in any member correspond exactly to the engineer's plans.

Form of Bars.—See that the form of each bar is the exact form called for by the engineer's plans.

Spacing of Bars.—See that the bars making up the reinforcement of any member are spaced exactly as shown by the engineer's plans.

Cleanliness of Steel.—See that the steel is cleaned from loose, scaly rust; a thin film of rust is not objectionable. See that the steel is free from oil or paint, both lessen the adhesion of the concrete. See that all adhering dirt is cleaned from the steel. See that concrete which has lodged on the steel and hardened during previous work is entirely removed before the reinforcement is finally concreted in.

Bending of Bars.—See that the bending of bars is done in such a manner that they do not break or crack at the bend. The bending force should be applied gradually and not with a jerk. Cold bending is always preferable; if hot bending is allowed see that the bending is not so done that the bar is weakened or burned. See that the bends are accurate in line and plane; the accompanying sketch, Fig. 1, shows the nature of the error to be watched for, the bends are not all in one plane *a f*, but the one at *d* is twisted to one side *d e' f'*.

Splicing of Bars.—See that the splicing of bars is done exactly according to the engineer's plans. Various forms of splices are in use and if not definitely instructed by the plans and specifications the inspector should learn from the engineer what form or forms will be acceptable.

Protruding Ends of Bars.—See that the ends of bars which are left protruding for splicing are, if they are likely not to be connected up for some little time, painted with cement paint to diminish rusting and so guarded that they are not bent down or knocked loose.

Fastening Reinforcement.—See that all reinforcement is securely fastened to preserve spacing, location, alinement, etc. Braces, blocks, suspenders, spacers, ties, etc., should be used in ample number to make certain of this feature. See that all temporary fastenings are removed as fast as the concreting reaches them.

Wiring Reinforcement.—See that the wiring of reinforcement at intersections is done carefully and strongly. Soft black iron wire, No. 16 to No. 18 gage, should be used and the ties should be made taut and be well fastened.

Placing Column Reinforcement.—See that the reinforcing frame is concentric with that of the column below, that the bars are vertical, that all ties are in place and are taut, that all splices are made, and that no part of the steel touches the walls of the form but that there is uniform open space all around between the steel and the form.

Spacing Column Bars.—See that templets are used particularly at bottom and top to insure accurate spacing of column bars. This is necessary to ensure that the bars of successive columns will fit when spliced. If the bars are bent as shown by Fig. 2, to connect with the bars of the column above, the spacing should be verified with particular care.

Tieing Column Bars.—See that the wire ties or hoops holding the vertical bars are taut, or, if punched straps or hooked bars are used, that they fit exactly. See that the vertical spacing of the ties is exact and according to plans. Figure 3 shows correct and incorrect way of fastening ties.

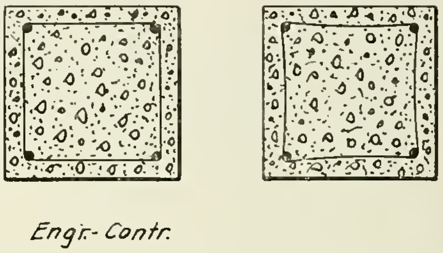


Fig. 3—Showing Correct and Incorrect Method of "Tieing" Column Bars.

Splicing Column Bars.—See that column bars are spliced exactly according to the plans. If a butt joint is specified see that the butting ends are square and the bearing uniform and that the joint is held true to line by sleeves or splice bars. If lap joints are allowed see that the wire wrapping, cable splices, etc., are made taut and secure. Various styles of column splices are shown by Fig. 4. The splice is a vital point and should be watched with care.

Placing of Beam Reinforcement.—See that beam reinforcement is placed symmetrical with the axis of the beam, that the bottom bars are held the required height above the bottom of the beam, that the proper space is maintained between the reinforcement and the sides of the beam, that the required connections are made at the ends of beam with the column bars or the reinforcement of abutting beams or walls, that all planes and lines are true, and that all parts of the reinforcement are wired together or otherwise held firmly to position.

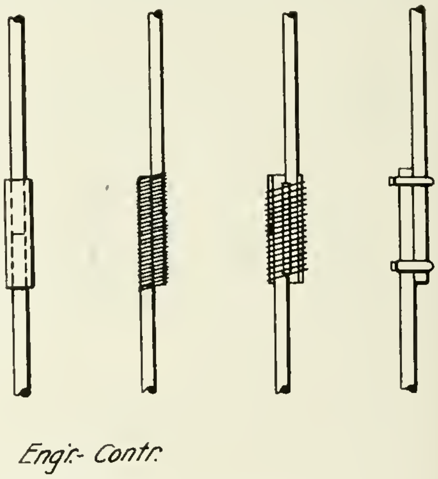


Fig. 4—Sketch Showing Typical Column Bar Splices.

Placing Wall Reinforcement.—See that the reinforcement is placed the required distances from the faces of the wall and in the exact planes laid down in the engineer's plans. See that the stipulated spacing of the bars is accurately followed. See that the bars are straight and true to line.

Placing Conduit Reinforcement.—See that the spacing of bars is according to plans, that the planes of the circumferential bars are perpendicular to the axis of the conduit, that the alinement of the longitudinal bars is parallel to the axis of the conduit, that the reinforcement as a whole is concentric with the axis of the conduit and conforms exactly to the circumferential curve called for by the engineer's plans.

Placing Reinforcement for Circular Tanks.—See that the spacing of bars is according to plans, that the circumferential rings are true circles, that splices are according to plans and are made with particular care, and that the reinforcement as a whole is concentric with the vertical axis.

"Elaterite," a New Waterproofing Paint for Concrete.

The requisites of a waterproofing paint for concrete may be summarized as follows: (1) It must be impervious to water. (2) It must have strong adhesive power. (3) It must not be affected by ordinary acid or alkaline waters. (4) It must be sufficiently elastic not to crack when the concrete expands or contracts. There has recently been put on the market a substance known as Elaterite Cement Waterproofing Paint, which is claimed to meet all of these requirements. Tests made by the Robert W. Hunt Co., Chicago, Ill., which consisted in immersing for three days 2x10-in. steel strips painted with two coats of the substance in 50 per cent solutions of nitric acid, sulphuric acid, hydrochloric acid and caustic soda and also in concentrated brine, showed the paint to be slightly attacked by the sulphuric and nitric acid solutions and by the caustic soda solution, but to be unaffected by the other solutions. It was also unaffected by exposure to strong fumes of the above acids and of sulphuretted hydrogen. In addition to laboratory tests the paint has been used with success on a number of concrete structures. Regarding one of these structures we have the following statement by Mr. J. B. Marsh, Marsh Bridge Co., Des Moines, Iowa, in a paper read before the Iowa Association of Cement Users:

Last summer we constructed a reservoir for Charles City, Iowa. The specifications called for 1-2-3 concrete, which we do not [illegible] impervious to water, and a coat of plaster ½-in. thick composed of 1 part cement and 2 parts sand to be placed after the walls [illegible]. As soon as it was completed and tested with water [illegible] [illegible].

To overcome the trouble we used a waterproofing material known as Elaterite Cement Waterproofing Paint, manufactured by the Elaterite Paint & Manufacturing Co., of Des Moines, Iowa, one coat of which absolutely stopped all leakage. I am satisfied that this paint more than anything else fulfills the requirements for a perfect waterproofing material.

In the same paper Mr. Marsh gives the following description of the composition and nature of this paint:

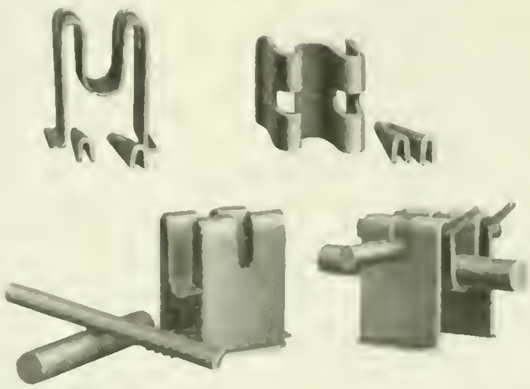
The base of this paint is a mineral [illegible] or elaterite, called also mineral rubber, [illegible] of the extreme [illegible], which is found in Colorado and Utah. [illegible] in acids or alkalis, [illegible] phoric acids which [illegible] having no effect whatever [illegible]. This property of insolubility [illegible] was prevented until [illegible] when a process was discovered [illegible] treatment was made possible. The original ore is not ground as is usual in preparing paint pigments, but by [illegible] discovered process it is converted [illegible] that enters into a thorough [illegible] carrying oils, so that [illegible] a coat is used, as long as [illegible] an absolutely waterproof surface is obtained.

For waterproofing the paint is applied cold, the first coat being well brushed in. Two coats are recommended. The application must be made on a dry, [illegible] surface. It is stated that one gallon will cover from 80 to 100 sq. ft. with two coats. This paint is made by the Elaterite Paint & Mfg. Co., Des Moines, Iowa.

A Combination Chair and Clip for Fastening Reinforcing Rods and Bars.

When separate bar reinforcement is used it is essential that the bars be fastened together at all points where they cross each other. Ordinarily the fastening is done by means of soft wire ties. Wire fastenings must be well made if they are to be firm and they can serve no other purpose than fastenings. In the accompanying sketch we show a substitute for wire fastenings which also serves the additional purpose of a chair or spacer to hold the reinforcement away from the forms and so insure it being embedded the proper distance from the surface of the concrete. The sketch shows the construction clearly; the carrying and distributing bars are inserted in their respective sockets and then the keys are driven tight and bent up at the small ends to lock them in place.

These "chairs" are made of a good weight and good quality of sheet steel, to give them ample strength against crushing down under such loads as are likely to come on the reinforcement. It will be noted too that the bottom edges of the chairs are bent to form flat feet and prevent cutting into the form boards. These chairs are made in any size specified and to fit any make of deformed bar as well as [illegible] bar. They are suitable for wall reinforcement [illegible] reinforcement. For wall reinforcement the bending of the bottom edge to form feet is omitted and for [illegible] so that the [illegible] vertical.



Combination Chair and Clip for Reinforcing Bars.

This combination chair and clip is made by the National Wire [illegible] Co., of Sandusky, Ohio.

* * *

The secretary of [illegible], Ind., has [illegible] an increase of the contract price for protective [illegible] from the present total of $[illegible] to $[illegible]. When the [illegible] an additional $[illegible] will be [illegible] for the enterprise.

The Civil Service Commission of the city of Chicago will hold examinations on May 11 and 13 [illegible] and a [illegible].

Experiments on the Electrolysis of Reinforced Concrete.*

By A. S. Langsdorf.

The possible corrosion of the steel reinforcement of concrete [illegible] is a matter that must appeal strongly to the engineer in view of the constantly increasing use of this kind of construction. The subject in general has received considerable attention, but mainly along the lines of the effect of atmospheric action. Some experiments have been made to determine the electrolytic behavior of reinforced concrete, but thus far not on an extensive scale. Probably the most notable published work in this direction is that of Mr. A. A. Knudson, of New York, whose results are to be found in the "Proceedings of the American Institute of Electrical Engineers" of February, 1907; this appears to be the first account of an experimental investigation of the subject.

The experiments here described were carried out, under the direction of the writer, during the winter and spring of 1908, by Mr. M. M. Glauber, at that time a senior student of electrical engineering in Washington University. The work was undertaken as a graduation thesis and was very carefully done. Its general plan was an amplification of that adopted by Mr. Knudson.

The tests made by Mr. Knudson were two in number. In the first test three specimens (Nos. 1, 2 and 3, respectively) were made by imbedding 2-in. pipe to a depth of 8 ins. in a mixture of equal parts of cement and sand; the kind of cement is not stated, but from the context it appears to have been a Portland cement. The mold was an ordinary metal pail, so that there was a thickness of between 3 and 4 ins. of concrete all around the pipe. The bottom of the pipe was closed by a watertight plug. The specimens were then placed in water, No. 2 in fresh water and Nos. 1 and 3 in sea water. Specimens 2 and 3 were then connected in series and a steady current of 0.1 ampere was passed through them from a storage battery, the current entering through the pipe and leaving through the concrete. Specimen No. 1 had no current through it, in order to compare its condition with that of the others at the end of the test. The test was continued for a little over 30 days, current being on continuously. The results showed an unexpected deterioration of the concrete, large cracks appearing in it. There were also strong evidences of electrolytic action on the pipes, a layer of rust having formed upon them which extended into the concrete, especially on the walls of the cracks; pitting of the pipes was very noticeable, and there was an appreciable loss of weight.

---

*A paper read before the Engineers' Club of St. Louis and printed in the Journal of the Association of Engineering Societies.

In the second set of tests two blocks (Nos. 4 and 5) were made, similar to the other three except that Rosendale cement was used. The test run was again continued for 30 days with the current constant at 0.1 ampere. The results were similar to those of the first test, except that No. 4 (in sea water) showed greater electrolytic action, a hole 1 in. by ⅜ in. having been eaten clear through the pipe. In the first test, Specimen No. 1, in sea water, but without current, was absolutely unaffected. A sledge hammer and chisel were required to break it open, and the pipe was clean and bright. In all the other specimens the concrete became soft and crumbly, so that in places a penknife could be easily thrust into it.

The tests made at Washington University were also divided into two parts, but 12 specimens were used in each part. All of the specimens consisted of 1½-in. pipe embedded to a depth of 9⅛ ins. in a 1-3-5 concrete, made rather wet and thoroughly tamped. The cement was Red Ring brand (made by the St. Louis Portland Cement Co.) and the aggregate was crushed limestone. The thickness of concrete all around the pipe was 2 ins. The specimens, after aging for about 50 days, were placed in 6-gal. glazed earthenware jars, raised above the bottom by wooden blocks, and were immersed in fresh water to within about 1 in. of the top of the concrete; fresh water was added as necessary to replace loss through evaporation. Fig. 1 shows the details of the specimens.

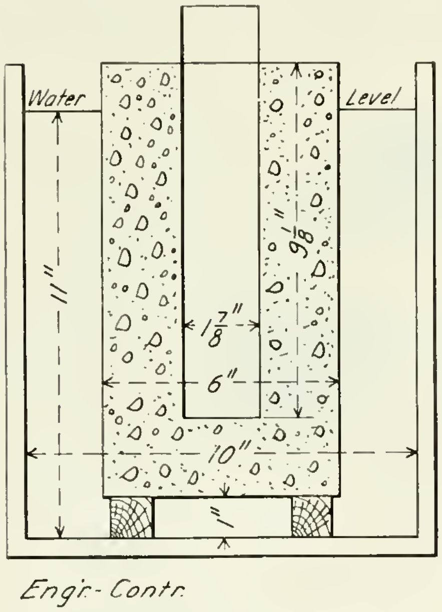


Fig. 1—Sketch Showing Arrangement of Specimen for Electrolysis Tests.

In the first run, eleven of the specimens were then connected in series and a current of 0.05 ampere was passed through them, the twelfth specimen being without current. The run was continued for 70 days continuously. (It will be noted that in this test the current was only half that used by Mr. Knudson, and the run was more than twice as long.) All of the pipes were weighed before embedding them in the concrete. At the end of each week one specimen was removed, broken open, and the pipe cleaned and reweighed, with the results shown in Fig. 2.

In the second run, which continued for 33 days, the specimens were connected as before, but the current strength was raised to 0.2 ampere. The curve showing loss of weight in this case is shown in Fig. 3; during both runs, readings of the drop of voltage around the specimens were taken at regular intervals. The apparent resistance per specimen, calculated by dividing the volts per sample by the current, varied in the first run from 660 ohms at the start to about 1,200 ohms at the end; in the second test it changed from about 50 ohms at the start to about 500 ohms at the end. Mr. Knudson found an apparent maximum resistance of from 300 to 400 ohms per specimen, but differences in this respect are to be expected because of variations in the density, or porosity, of the samples. It is to be understood that these resistances are apparent only, for they include the effect of a very considerable polarization.

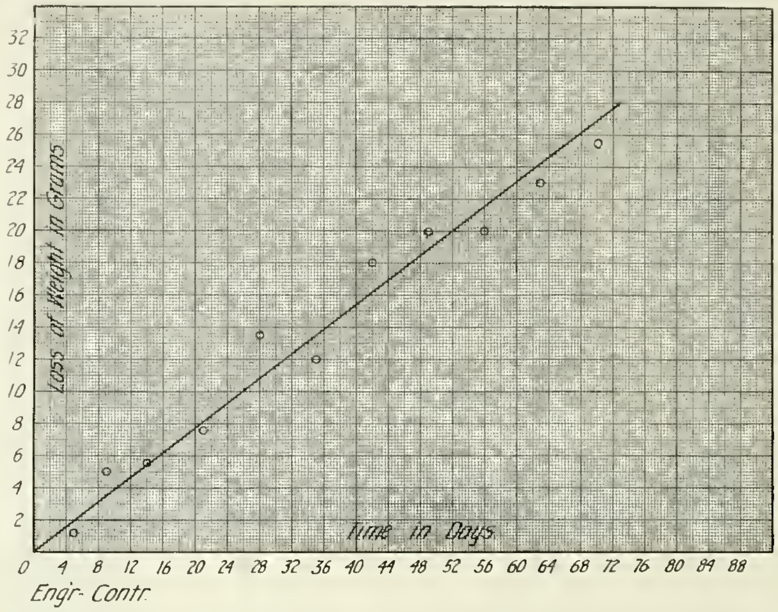


Fig. 3—Showing Loss in Weight of Concrete by Electrolysis at End of Week.

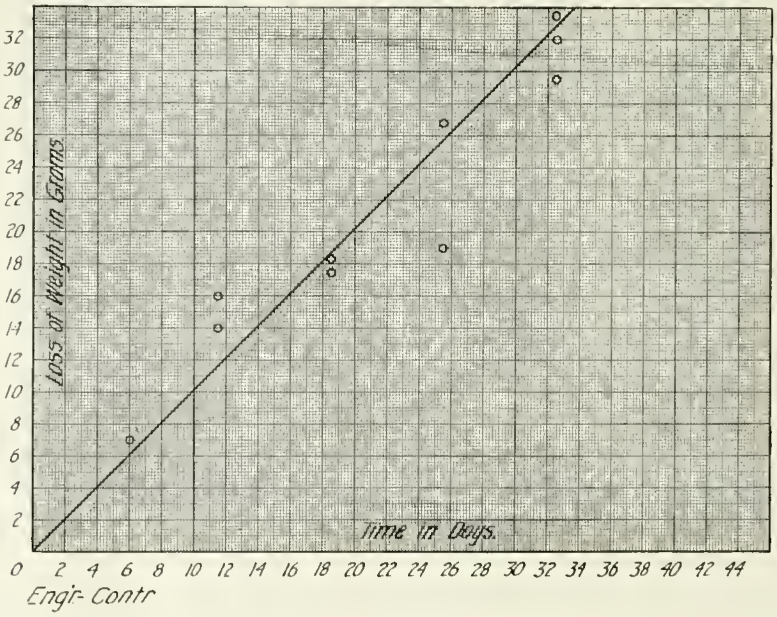


Fig. 2—Showing Loss in Weight of Concrete by Electrolysis at End of 33 Days.

The specimens after their removal from the circuit show large radial cracks that formed in the concrete; and some show also a flaky white deposit that formed on the outside surface. Lack of time prevented making an analysis of this deposit, but this will be done in a further series of tests.

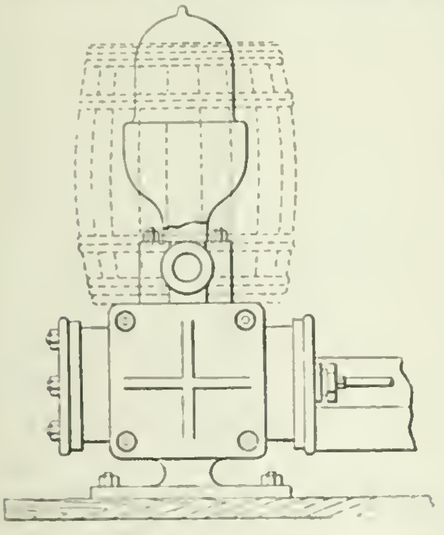
The softening of the concrete observed by Mr. Knudson was confirmed in these tests, but it was not so marked as reported by him, probably on account of the different mixture used. But the electrolytic action on the embedded metal was very strong, as shown by the curve of loss of weight. Whereas the specimens not subjected to the current remained clean and bright, the others developed a coating of rust whose thickness increased with the duration of current flow, and in all cases where cracks developed a coating of rust was deposited on the walls of the cracks.

The cracking of the concrete may possibly be explained by the fact that the layer of rust is of rather loose consistency, so that its density is less and its volume greater than that of the original material, thus giving rise to a bursting force. The fact that the cracks are mainly radial seems to support this hypothesis.

Mr. Knudson's results, as well as those here described, indicate quite clearly that great caution must be used in the construction of reinforced concrete structures where the conditions are similar to those of the tests, such, for example, as might be found in the case of bridge abutments or concrete sewers in the neighborhood of grounded railway circuits. Further information is needed as to the extent to which the reinforcement of such structures, when buried in damp or wet earth, may become part of the return circuit of trolley lines, and also to determine the insulating effect of waterproofing ingredients in the concrete. It is the intention of the writer to take up these subjects in a further investigation, and it is to be hoped that others will also undertake the study of this important subject.

Method of Repairing a Broken Pump With Concrete.

Concrete has been put to many novel uses; few have been more novel, however, than that illustrated by the accompanying sketch, reprinted from the "American Machinist." The story is that away back in the country a water power plant was being built to electrify a town down the valley. A steam pump was keeping the water out of the excavation and an unlucky swing of the derrick boom caused a loaded bucket to hit the air chamber of the pump and break it off, as shown. It was miles to a repair shop and a delay of several days seemed inevitable, but the contractor was ingenious. The air chamber was put back in position, an empty barrel minus both heads was placed over it with a notch cut out of one side to clear the discharge pipe. Holes and openings were plugged and then the barrel was filled with concrete. After waiting over night and the next day for the concrete to harden the pump was started and it ran all right until the work was finished.



Method of Repairing Broken Air Chamber of a Pump With Concrete.

For the ten-year period from 1891 to 1900 the number of fatalities in coal mines of Belgium per 10,000 workmen was 10.81 per annum. In the metallic ore mines the number of workmen who have been killed by accident is one-third that in the coal mines.

Earth and Rock Section

Note: This Section is devoted to methods and costs of excavating earth and rock and building embankments. It will cover the grading of roads and railroads, diking and canal work, dredging, building reservoirs and earth dams, sewer and water pipe trenching, quarrying, etc.

Methods of Driving Headings in Rock Tunnels with Special Reference to the Work in the Loetschberg Tunnel.*

BY W. L. SAUNDERS.

(Supplementing the comments made by Mr. Saunders on the Loetschberg Tunnel work we publish a paper by Mr. Walter J. Aims describing the work in more detail. So far as was possible without destroying the sense we have eliminated from Mr. Saunders' paper all data which are also given by Mr. Aims.—Editor.)

This paper deals specifically with heading driving as distinguished from the broader term tunnel driving. A heading is a pilot or path-finder for the main tunnel. Some headings are complete tunnels in themselves, that is, conditions at times warrant driving a heading the full diameter of the proposed tunnel. A tunnel 10 ft. in diameter might be driven to advantage through a single heading, provided the nature of the material admits, but it usually pays to drive rock tunnels of large diameter through the heading-and-bench system. Much depends upon the material, as in soft ground tunnels of much larger diameter are driven in a single heading.

In mines, the tunnels, drifts, cross-cuts, adits, etc., are usually of small diameter, hence the driving of headings applies to completed tunnels in mining work, except, of course, in cases like drainage tunnels and main entries leading into coal mines, where conditions call for tunnels of large diameter, approximating those driven for railway service. In building aqueducts the tunnels are driven from 6 to 8 ft. in diameter up to 15 or 20 ft., while in railway service the dimensions vary from 18 to 30 ft. in diameter.

There is no department of rock excavation so difficult as that of heading driving. This work also belongs to the most expensive class in rock excavation. A heading is driven directly in the solid. There are no lines of lesser resistance towards which to direct the energy of the blast, but the material must be blown out by main force. The completion of the heading simplifies all the rest of the work of excavation. It is easy, for instance, to enlarge a heading either from above, below or on the sides by breaking towards the open face through holes approximately at right angles to the axis of the heading, or the enlargement sometimes takes place by holes driven outside of the heading running approximately parallel with it, the rock being broken into the heading. All of this enlargement work, or stoping, involves little difficulty, and a minimum of explosive is required, because there is an open end or face towards which the energy of the blast is directed.

Fig. 1 shows the usual arrangement of heading holes in tunnel driving. After blasting the center cut holes and the first of the side-round holes, the appearance of the heading in elevation will be about as shown in Fig. 2. The latter illustration shows the second set of side round holes connected up by wires ready for firing.

Fig. 3 shows in plan and elevation typical conditions where tunnel headings are to be enlarged. This is stoping work, and because of the advantageous position which the holes can be given, the removal of the rock may be accomplished at much less expense per cubic yard than in the case of heading driving.

Driving seems to be the fitting term to use for tunnel construction, because, from the beginning to the end, every other consideration is sacrificed to progress. The tunnel is worthless until completed, and the capital involved in its construction is locked up and unprofitable. During the construction of the Simplon tunnel in the Alps premiums were offered exceeding $1,000,000 for increased speed in driving. This tunnel is the longest railway tunnel in the world, being 12.25 miles long, and it holds the record for speed in heading progress.

Progress in heading driving is dependent, first, upon an efficient boring apparatus and system, and following closely upon this and of perhaps equal importance, is the system of blasting. The nature of the rock has a great deal to do with heading progress. A hard rock which shatters easily is usually more favorable than a tough, soft material. The direction of the dip or of the cleavage of the rock has a good deal to do with progress. Fissures, pressure in the rock, water-bearing strata, heat, gas and soft spots resulting in falls are hindrances to progress.

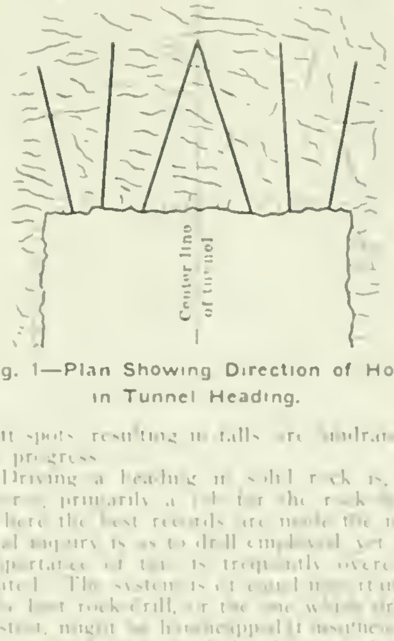


Fig. 1—Plan Showing Direction of Holes in Tunnel Heading.

Driving a heading in solid rock is, of course, primarily a job for the rock drill. Where the best records are made the general inquiry is as to drill employed, yet the importance of this is frequently overestimated. The system is of equal importance. The best rock drill, or the one which drills fastest, might be handicapped if insufficiently mounted, since the holes driven in headings are invariably at moderate depths, so that much of the time is employed in changing the drill from one hole to another, changing steels, etc.

Too little importance is given to the position in which a rock drill is mounted. An illustration of this is shown by comparing the drilling capacity of a machine when used, for instance, on a tripod or a column with that of the same type and size of rock drill mounted on a gadder frame or quarry bar. The usual work of a rock drill in average material is from 50 to 60 ft.

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*Condensed from a paper read at the New Haven meeting, February, 1909, of the American Institute of Mining Engineers.

ft. of hole in a day of 10 hrs. This machine, when mounted on a gadder frame or quarry bar, will do 350 lin. ft. of hole in the same time, the difference being made up, not in the drilling capacity, but in the facilities afforded for rapidly changing from one hole to another.

The remarkable records in tunnel driving made by the hydraulic drills used at the Simplon tunnel, referred to later on in this paper, have always been attributed to the efficiency of the boring machine. These Simplon headings were driven at the rate of about 20 lin. ft. in 24 hrs., and in hard rock, while American tunnel-driving seldom exceeds 10 ft. in 24 hrs., when driving in hard rock, so that here we have a difference of 2 to 1 against the American system. It is a common thing to say that a single track railway tunnel driven from two headings will progress at the rate of a mile a year. This is our average progress under average conditions. In the Alps the tunnels are driven from two headings at the rate of about 2 miles a year. These data are, of course, general, and do not take into consideration delays due to falls, destructive pressure in the rock, hot water streams, etc

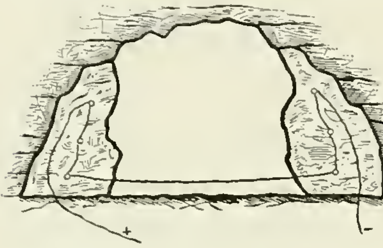

Fig. 2—Method of Shooting Side Cut Holes in Tunnel Heading.

It will be seen later on that the remarkable records made at the Simplon have practically been equaled by the work now going on in the Loetschberg tunnel, this latter being equipped with American percussive drills mounted on carriages similar to those used at the Simplon.

It may safely be said that the discovery of gunpowder, followed by that of dynamite, is the greatest invention that has been given us in facilitating tunnel driving. Next comes the power-drill. In ancient times rock excavation under ground was limited to hand tools, wedges, etc., assisted by a system of excavation known as "fire-setting," which consisted in heating the rock and suddenly cooling it with water, thus disintegrating it.

AMERICAN TUNNELING RECORDS.

The following are some of the best American tunneling records, arranged progressively. In some cases the records are those of complete tunnels and in others of the heading only, but as a heading is in itself a tunnel they may all be considered in the same class as records of progress.* The figures represent monthly progress:

Musconetcong, N. J., 1872	144 ft.
Nesquehoning, Pa., 1871	165 ft.
Hoosac, Mass., 1865-1873	184 ft.
Busk, Colo., 1890-1893	202.5 ft.
Stampede, Wash., 1886-1888	271 ft.
Cascade, Wash., 1897-1900	*301 ft.
Aspen, Wyo., 1901	306 ft.
Bitter Root Mts., 1908	340 ft.
Kellogg, Idaho, 1898	345 ft.
Raton, Colo., 1907	412 ft.
Sutro, Nev., 1869-1877	417 ft.
New Croton Aqueduct, 1887 (in 1 wk.)	127 ft.
Gunnison, Colo., 1908	449 ft.
Elizabeth Lake, Colo., 1908	466 ft.

*Another record for this tunnel is: Completed tunnel, both ends, November, 1899, 527 ft.

There is some question as to whether the Sutro record is for one heading or two, so that its place in the list is questionable; also, notwithstanding the mental allowance for the differences in working conditions, the Raton tunnel (Eng.-Contr., March 3, 1909) can hardly be considered as in the same class with the others, as the material, not to call it rock, was so soft that most of the drilling was done with coal augurs, and a steam shovel was used to excavate the bench. The tunnel was finally lined with concrete, 2 ft. thick.

The record of the new Croton Aqueduct, in 1887, of 127 ft. in one week, was a deliberate drive for one week for the purpose of making a record. This was done regardless of expense or the amount of explosive consumed. I was on the ground and know that while the figures represent the true progress made, yet they are reliable only in that they show what may possibly be done, and not what ought to be done or what can be done, under similar circumstances. The week following that during which the record was made the progress fell off about one-half.

The record of the Bitter Root Mts. tunnel, driven by Winston Bros. Co., "is probably the record rate of progress on American railway tunnels driven the full width of the arch in hard rock." This tunnel was driven by the regular top heading system. The section of the tunnel is rectangular with semi-circular roof arch. The width is 21.33 ft.; height to springing, 15.25 ft.; height to crown, 25.92 ft.; rock, quartzite, slightly laminated. In the six months beginning with June, 1908, the averages were: East heading, 289.3 ft. per month; west heading, 281.2 ft.; both headings, 570.5 ft.; bench, both ends, 632.5 ft. The average progress, both ends, for the first 11 months of 1908 was 537.6 ft. per mouth.

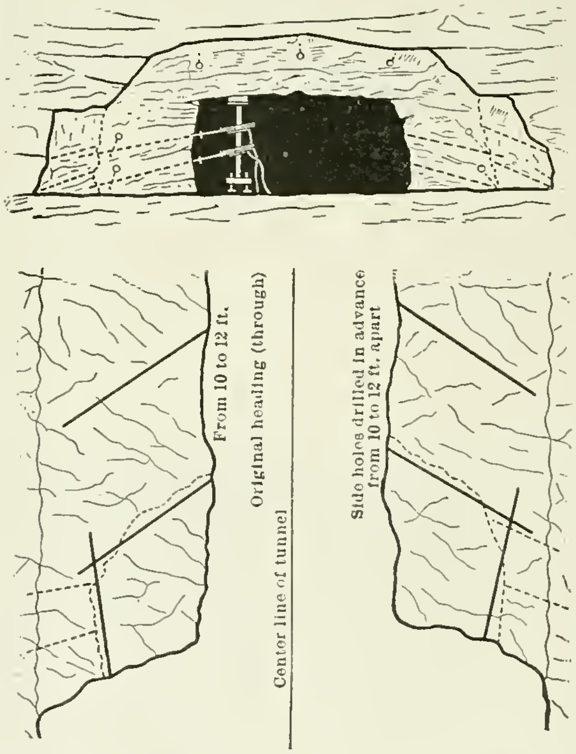
From 10 to 12 ft.
Original heading (through)
Center line of tunnel
Side holes drilled in advance from 10 to 12 ft. apart

Fig. 3—Method of Enlarging Tunnel Heading.

This tunnel is timbered throughout except for 1,302 ft. of the west end. The section is 18 ft. 6 in. by 25 ft. in the clear, or inside the timber. Perhaps the most gratifying feature of the work is the increase of speed as the work progressed, as shown below:

Heading—		
One end	June, 333 ft.	Nov., 340 ft.
Both ends	Aug., 628 ft.	Nov., 608 ft.
Bench—		
One end	Aug., 415 ft.	Nov., 527 ft.
Both ends	June, 631 ft.	Nov., 855 ft.

In the west heading no advance was made for the last six days of November, as a seam of very wet running ground, talc, was struck, necessitating a change of arrangements. If the rate had been maintained for these six days the total would have been 674 instead of 608 ft., thus exceeding the previous record.

As is to be always remembered, each of these tunnels differs from all the rest as to the conditions, favorable or otherwise, so that inferences from the comparing of records are not necessarily authoritative or final.

It happens that the last two on the list, the Gunnison and Elizabeth Lake tunnels, are probably as fairly comparable with each other as any, with the interesting particular that the two were driven by different and contrasting methods. Both are in granite and about 12 by 12 ft. in section. The Gunnison tunnel was made by driving the section one-half size; that is, by a smaller heading 6 by 12 ft. The Elizabeth Lake tunnel was driven full size by the lower heading method.

EUROPEAN TUNNELING RECORDS.

Following our list of American high records we have now a few representing the best European practice. These are arranged progressively, and after the first two or three items this list would tag on to the other, showing an increasing rate from beginning to end of the combined record, only that, unfortunately, these later records generally antedate or are contemporaneous with the American. The highest monthly records of European tunneling show not only larger figures but a better maintenance of approximately the maximum, month after month. In some of the cases here following several successive monthly records are given:

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*See Engr.-Contr., Dec. 9, 1909, p. 394, for other American records.

Mont Cenis, 1857-1870, [illegible] ft.

St. Gotthard, 1872-1881, [illegible] ft. (with a year's average of [illegible] ft. This is the only Alpine tunnel driven with top heading.)

Ricken, [illegible] ft. (by hand drilling entirely. Work was stopped on this tunnel nearly a year on account of fire damp.)

Bosruck, [illegible] ft.

Karawanken, [illegible] ft.

Arlberg, 1880-1883, east heading, [illegible] to 613, 617 ft. (percussion drills).

Arlberg, west heading, [illegible] 641 ft. (hydraulic rotary drills).

Albula, 1899-1902, [illegible] ft. (hydraulic rotary drills).

Tauern, 548 ft., with an average of nearly 425 ft.

Loetschberg, [illegible] ft.

Simplon, 1898-1905, north heading, 652 ft.

Simplon, south heading, [illegible] ft. (This is the world's record.)

Seven or eight of the best records are so nearly alike that the differences might easily be accounted for by the varying hardness of the rock or other material conditions, without implying anything as to the superiority of the apparatus or the system employed in either case.

The Simplon and the Loetschberg tunnels are perhaps the most interesting of the list, and they are quite intimately related to each other. The Loetschberg tunnel, as we know, has had troubles of its own, work at the north end being stopped absolutely after a frightful and unusual accident. Though the line passed under the Kander River, there was 600 ft. of covering over the tunnel at this point, 300 ft. of this being known to be bad, but the engineers seem to have taken the chances on the other 300 ft., and the chances proved to be deadly certainties against them. The entire depth caved in, forming a funnel-shaped hole from the bottom of the river, killing 26 men, causing a loss of all the machinery, and leaving a problem in tunnel work such as, perhaps, was never encountered before.

The work at the southern end of the tunnel from Goppenstein, Valais, Switzerland, is still going on at full speed, there having been an advance of nearly 2.5 miles up to the present time. The altitude of the work is about 4000 ft. above sea-level. The tunnel is built for double tracks, with an area of cross section of 592.5 sq. feet.

What is known as the Belgian method is employed in driving the tunnel, there being one principal bottom heading of 60 sq. ft. and an upper heading of 35 sq. ft. Every 600 ft. upraises are made from this bottom heading, and a top heading is started from each of these upraises. From the top heading the work of taking out the tunnel to its full section is carried on in bench work. Besides the upraises, chutes about 2 ft. square are blasted out between the bottom heading and the top, where the muck can be dropped into trains of cars below. To make sure that there will be no dropping of the middle portion, this is supported by timbers as long as necessary, the timbering being successively removed and carried forward. The sides are finally trimmed out and the concrete lining is placed.

[illegible] A longitudinal section of the Loetschberg tunnel, showing the upper and lower headings, upraises, chutes, etc., with drills in position, a transverse section of the tunnel showing the position and size of the top and bottom headings in relation to the completed tunnel, and an enlarged outline elevation of the tunnel carriage is shown by Fig. 1 in Mr. Apel's article.

The responsibility for the total advance thus always remains with the bottom heading, and here is the most interesting feature of the work. There is a single track, about 30 in. gage, in the bottom heading, this heading being widened out where the upraises are to be made, and the track being turned out at these points. On this track travels a special car, which carries a normally horizontal, [illegible] counterbalanced steel beam, upon the forward end of which is secured a horizontal bar, and upon this bar are four drills. The swinging of the beam upward or downward and the placing of the drills above or below the bar gives them all the positions for the 12 or 14 holes usually required for each round.

The original car and mounting designed for this service may be described as too much of a good thing, and it was never used. On this car were two of the balanced, vertically swinging beams, each carrying its shaft or tunnel bar, and on each of these three or four drills would have been mounted. The ends of these two bars were telescoped, and it was designed to clamp and hold the bars in working position by forcing the ends out against the sides of the heading by hydraulic pressure. An important and conspicuous feature of the car was, therefore, an air operated duplex water pump to furnish and maintain the required pressure. The car actually used was a much simpler affair.

This car was built by the Ingersoll-Rand Co. It carries only a single balanced, vertically swinging beam with a single bar pivoted to swing horizontally above the forward end of it, and the bar is secured against the sides of the heading by the usual jack screws, so that the water pump is dispensed with. The bar is pivoted above the beam so that when the car is run backward or forward the bar may be swung around, above and parallel with the beam, leaving no interfering projections to catch the sides of the heading. Four 3⅝-in. Ingersoll-Rand drills are mounted on the bar, each, of course, with a separate air connection, but all connecting by a manifold with a single hose at the rear of the car.

Either 12 or 14 holes are drilled in each round. These are 4 ft. deep and 2 in. at the bottom, in four vertical rows, the inner rows running nearly parallel with the tunnel axis the same as the rest. As soon as the holes are all drilled the bar is swung around straight and the car is run back to the last turnout until the blasting is done. Before the blasting, a ⅜-in. steel plate, 6 ft. 6 in. by 3 ft. 3 in. in area, is laid down just ahead of the end of the track, and after the blasting is over a cut is quickly made through the center of the muck pile down to the plate, and the tunnel carriage is run forward on this, the bar is set again, and the drills begin the top row of holes. Mucking out continues during the drilling.

The use of this carriage facilitates the mucking to a considerable degree. After the blast in the usual American tunnel there is a mass of muck reaching nearly to the roof piled up in front and close to the face of the heading. This muck is [illegible] away only to a sufficient degree to allow the men to climb over it and dig holes close to the face for the purpose of placing the columns which carry the rock drills. The use of this carriage, with the bar which carries the drills projecting forward some 12 ft. or more from the frame, requires that the first mucking be done on the steel plate on the floor and only sufficient to make a trench through the center of the heading, so that the tunnel carriage may reach close enough to enable the drills to begin operations at the top holes over the muck. Here we have the drills at work earlier than with the American system, and the muckers have a better opportunity to load the cars, because the material is scattered on each side of the heading instead of being piled up only at the face.

Where the rock drills are mounted on a bar carried by a tunnel carriage it is easier to keep them in condition, free from muck and grit, than with the American system, where they are detached from the columns and laid on the floor. This is an important point, not only in reducing maintenance expense and preventing wear in the cylinders and other moving parts, but also in lessening the [illegible] in keeping the stuffing boxes tight, resulting in a smaller leakage of air.

Blasting is done by the ordinary method, the fuses being all fired at the same time, but the length of the fuses is such that the center holes are fired first. By this system time is saved, but there is some danger of missed holes, and to minimize this three fuses are used in the bottom holes and two in all the others. The explosive used is 60 per cent dynamite, made at Brieg. The center holes are charged with 2.7 kg. (6 lbs.) each and the average total charge for the 12 or 14 holes is from 24 to 26 kg. (53 to 57 lbs.). The holes are not very deep, not exceeding 4 ft., starting 2.5 in. and finishing 2 in., to take cartridges up to 50 mm., or nearly 2 in., in diameter.

To accomplish the rapid rate of advance which is maintained the number of men employed is large. Night is, of course, the same as day, and the work is continuous. There are three 8-hr. shifts, and each shift is expected to drill two rounds and to shoot twice, making about 7 ft. per shift, or from 18 to 21 ft. per day. A liberal bonus is paid to the men all around—Italians from the Northern provinces—for all speed above a certain rate. Each separate drill has 2 men, and 2 additional helpers handle the steels. 10 men clear away after the shot and all the 20 men work together for the placing of the truck and the laying of its side track, located about every 600 feet.

Experience has shown that the truck is indispensable if the rapid advance is to be maintained, though it is not without its objectionable features. The fact that all the four drills are [illegible] in the same horizontal plane makes it difficult to give the upwardly inclined holes just the same angle they could have if the drills were on separate columns, and to get a clean break to the bottom of the hole more explosive must be used.

This disadvantage of a horizontal bar over the vertical column is more than compensated for by the readiness with which the bar may be set in place and locked. One bar only has to be jacked, and that across the heading horizontally against the walls, which are usually rigid, while with the column mounting [illegible] must be placed in position, [illegible] each one needs a firm base, which is not always available close to the face of a heading just after the blast. But this is not all, nor is this the most important feature of the tunnel carriage system. By its use and because of the rigidity which it affords the stable mounting of the rock drill [illegible] it is possible to put in a large number of shallow holes of large diameter as against the American system, which is a small number of deep holes of small diameter. It must be understood that, where a rock drill is mounted upon a column, [illegible] has been occupied in placing it in position, setting the jack screws tight and pointing the drill, [illegible] keeping it there and putting in as deep a hole as we reasonably can, consistent with the dimensions of the heading.

ing, the nature of the rock, and the angle of the hole.

Other things being equal, a deep hole can be drilled faster than two or more shallow holes, the combined depths of which are equal to the deep hole. The difference is made up in the time lost in changing the mounting, whether that mounting be a column or a tripod. The deeper the holes are driven the smaller is the diameter of the hole at the bottom, and we know, of course, that it is at the bottom of the holes that we want the greater amount of concentrated explosive force, and that the larger the hole is at the bottom the better is the effect of the blast.

A theoretically perfect hole would be one larger at the bottom than at the orifice, but this is not practical in tunnel work, hence we must suffer the loss of gage, and by an excessive amount of explosive, by good tamping, and other means, try to make up for this handicap.

Another habit which we have fallen into is, that too small a number of holes are inserted in the heading. This is because we have found it difficult to make reasonable progress in hard rock by drilling an adequate number of holes, owing mainly to the fact that the mounting must be changed from one place to another. Having the habit of deep holes, we find it necessary to start them in a certain particular place, so that they will bottom just where we want them in order to "break the ground." Now, it is just in this that we see the disadvantage under which the column system suffers.

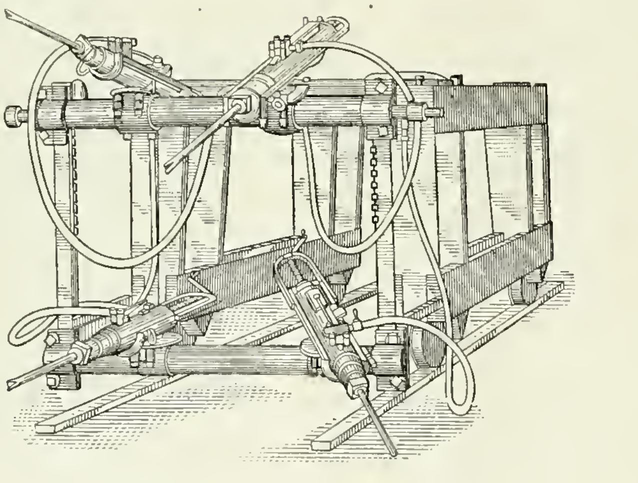

Fig. 4—Tunnel Carriage With Old Burleigh Drills.

Having the horizontal bar used in the Loetschberg tunnel with four percussive drills mounted upon it, and this bar being practically balanced on a little tunnel car riage and easily jacked in place across the walls, we begin putting in a hole with each machine. If one bottoms its hole ahead of the others it is simply swung on its radius, the center of the axis being the bar itself, and another hole put in. All of these holes are shallow, and being shallow they are naturally of large diameter. One meter is the usual depth, or a maximum of 4 ft. This is from one-half to one-third the usual depth of hole inserted in a tunnel heading under the American column system; and because the holes are shallow it is not necessary to start them in so exact a position, but as long as we have enough of them, and use plenty of dynamite, the rock is thrown out in pieces of smaller size, and usually farther away from the face of the heading, than where the blast is from a deep hole, even though it may be directed to meet another hole, the two holes practically joining at the bottom, forming a wedge, and acting to concentrate the force by means of which the center cut is made.

This tunnel carriage is so simple and so heavy that it is practically indestructible.

What we have always understood as a tunnel carriage is a cumbersome affair, quite different from that used in the Loetschberg tunnel. A carriage was the first form of mounting adopted when rock drills were used to drive the Hoosac and other American tunnels. The carriage usually occupied the entire area of the heading, and was a hindrance to progress rather than otherwise.

Fig. 4 shows the Burleigh drill carriage used in the Hoosac and other early tunnels. This is the original form of tunnel carriage, and attention is drawn to a comparison between the Burleigh carriage and that used in the Loetschberg tunnel (see Fig. 2 in Mr. Aims' article—Ed.). The Burleigh carriage occupied too much space and was too cumbersome for practical tunnel driving. It did not afford facilities for mucking, and too much delay occurred after a blast before the carriage could be run close enough to the heading for the drills to begin work. The Loetschberg machine, with its small truck and short wheel base, need not approach very close to the heading because of its overhanging arm. The two to four drills, mounted on the single shaft carried by the arm, are quite sufficient for all ordinary heading purposes.

The Alpine tunnel carriage is a little truck with a wheel base of only about 4 ft. and a gage on the track which corresponds to the regular track used in the heading for conveying the material. It consists of a pair of axles with four wheels, and a cast iron body with a central support, on which the I-beam carrying the shaft bar is pivoted. On the opposite end of this I-beam is a heavy weight by which the bar is balanced, and by means of a vertical screw and a nut operated by a hand wheel this I-beam is see-sawed to any position desired.

Next in importance to the system of mounting the drills is the system of blasting. Because of the larger number of holes, the greater diameter, and because the holes are not directed on lines of maximum breaking efficiency, a great deal more explosive is used than in the American system, but dynamite is cheap—much cheaper in fact than time and labor. To blast by fuse instead of by electric battery would seem to be a step backward, and yet in this class of work it has some advantages. With the electric system the heading is wired and the center or cut holes blasted first. After this the wires leading to the side rounds are connected, and it frequently happens that the first blast has damaged the wires or has covered them so that considerable time is lost in getting ready for the side round blast. Broken wires result in mis-fires. The use of the time-fuses means that the whole heading is fired practically in one operation, though there is a lapse of a few seconds between the discharges, owing to a difference in the lengths of the fuses, the shorter fuses being connected with the center cut holes, and the length of fuse being increased in proportion as the side rounds are blasted from the center. Misfires also occur with the fuse system, but this is minimized by employing two or three fuses and caps in each hole.

It takes less time to connect these holes by fuse and to fire them than it does to connect the wires, to see that they are properly insulated, to couple up the leading wires, and to discharge the battery, especially so when through the system of deep-cut holes it is found necessary in American tunnels to blast the center first and the side rounds alternately afterwards.

Other details of the tunnel work as a whole need not be considered in the present paper. The upper heading is driven to keep pace with the lower one, but in the individual faces here the rate of advance is slower. For this work two 3.5-in. drills are used on 5.5-in. columns, and of course fewer men are called for. This heading has a section area of about 40 sq. ft., and the daily advance of each face is about 10 ft.

An inland waterway project that has been under consideration for at least 15 years is the construction of a canal between Lake Superior and the Mississippi River, by way of the St. Croix River. This route was investigated long ago by Col. Clinton D. Sears, who reported that a canal of about 210 miles length with 5 ft. depth on the sills of the locks would cost about $6,000,000, and would require about $350,000 annually for operation and maintenance. In his opinion this canal was not an urgent public necessity. The river and habor act approved last month called for a further report on the route, as to whether existing conditions render the project feasible and practicable at the present time. Accordingly Lieut.-Col. Graham D. Fitch, who is in charge of the United States Engineer Office at Duluth, has undertaken to gather all possible information and opinions on the subject, in order that the report may be as complete as practicable. This investigation is unique because he has requested the press of Minnesota and Wisconsin to bring the matter to the attention of all interested in the subject, so that anyone affected by transportation facilities in the district served by the proposed canal may have an opportunity of presenting his views in writing.

During 30 years of asbestos production Canada, which leads the world in the output of this mineral, has produced $20,000,000 worth, stated Geologist J. A. Dresser in an address before the Canadian Mining Institute at Windsor on March 5. In 1878 the output was 50 tons, while in 1908 it was 65,531 tons, worth $2,547,507. The product has been hitherto manufactured in the United States and Europe, but large works for the making of asbestos articles are being installed in Canada.

Rapid Methods in Driving Alpine Tunnels.*

BY WALTER L. [illegible]†

Records of speed attained in driving rock tunnel headings show that the progress made in Alpine tunnels has far exceeded the best American records and it therefore becomes a matter of considerable importance to determine the reasons why so great a difference should exist.

The best American record is now claimed for the Elizabeth Lake tunnel of the Los Angeles aqueduct work, where 466 feet is said to have been driven in a single heading during October, 1908. But even this record falls far short of that made at the Simplon tunnel in the Alps, where 685 ft was driven in one heading during July, 1904.

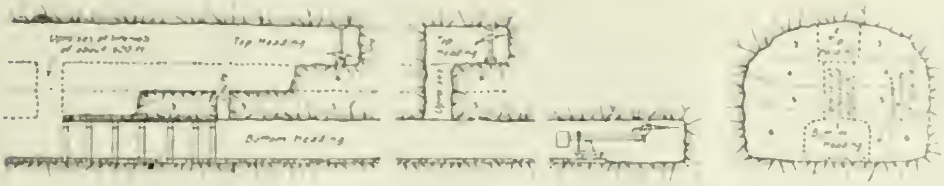

Fig. 1—Method of Attack and Sequence of Operations.

The writer has recently visited the Loetschberg tunnel now being built between Kandersteg and Goppenstein near the line of the Gemmi Pass, Switzerland. It is on the line of the railway to connect Berne with the Simplon tunnel road to Italy. In this tunnel similar monthly progress to that made at the Simplon is now being accomplished, and the results of the writer's observations are herewith appended.

This tunnel when completed will be about 8½ miles long. Near the northern portal the tunnel passes under the Kander River and it is at this point that the serious cave-in, extending up to the river bed, occurred last July. This accident occasioned the temporary abandonment of work in that heading until plans shall have been decided upon for meeting this difficulty. The work, therefore, is at present being carried on from the southern portal only.

The experience gained in driving the Simplon tunnel is being used to advantage at the Loetschberg, with the difference, however, that while the Simplon was driven with rotary drills of foreign manufacture, the Loetschberg is being driven with American air driven percussion drills made by the Ingersoll Rand Company.

The tunnel is designed for a double track railway and has a cross-sectional area of about 66 sq. yds. The bottom heading method of construction can therefore be used to advantage. This bottom heading is about 6 ft 6 ins. high by 10 ft wide (Fig. 1). Every 600 ft upraises are made from the bottom heading and a top heading [illegible] sectional area [illegible]. From these top headings the [illegible] ing out the tunnel to its full section is carried on [illegible] work, timbering being erected in the bottom heading during the first stage to prevent the [illegible] between the top workings and the bottom heading breaking through and damaging the track below. As soon as these top excavations are connected with the bottom heading the timbering is removed to be used again at another point. The sides are then trimmed out and the concrete lining is placed, largely made up of beton or concrete blocks backed with concrete.

There is but a single track in the bottom heading about 2 ft. 6 ins. gage, with turnouts every 600 ft. where the upraises occur, the bottom heading being widened out at these points to accommodate the turnouts. Numerous chutes about 2 ft. square are also blasted out between the bottom heading and the top workings through which the muck is dumped into the trains of cars in the bottom heading.

By this method of working, there is no difficulty in keeping pace with the heading, and in taking out the full tunnel section, at the same time no delay is occasioned to the heading operations. The speed of the heading, therefore, is the speed of the completed tunnel and hence it is the methods used at the heading upon which the main interest centers.

The secret of the great speed in these Alpine tunnel headings appears to be that a very careful study has been made of the various causes of delay in the successive operations of drilling, blasting, mucking out, and setting up the drills again, with the result that a radically different method of mounting the drills in the heading has been employed and also that a different system of blasting is used from that practiced in America.

In the mounting of the drills, the return [illegible] very [illegible] in conception, but [illegible] between it and the drill carriages used in the early tunneling operations in this country.

The drill carriage (Fig. 2) at the Loetschberg tunnel consists of a small frame with a platform about 4 ft. running on a regular heading track. Mounted on the truck and hinged to swing horizontally is an I beam reinforced to give it lateral stiffness. On the forward end of the I beam there is mounted what we in America would call a shaft bar hinged to swing horizontally. On the opposite end of the I beam is a counterweight. Four drills (F 94) are mounted on this shaft bar, the compressed air connections from these drills running back to one hose connection at the rear of the truck. The accompanying cut illustrates the main features of the drill carriage. When not in use the shaft bar is swung so that it lies directly over the I beam, and the carriage can then be run anywhere over the heading tracks, occupying no more room in the heading than a couple of muck cars.

Before blasting a plate of steel about 6 ft 6 ins. long, 3 ft 3 ins. wide and ⅜ ins. in thickness is laid down just ahead of the end of the track. After the blasting is over, a cut is quickly made through the center of the muck pile down to this steel plate sufficiently wide to allow the arm of the drill carriage to introduce the bar carrying the drills into the top of the heading, the drill carriage running on the steel plate laid down ahead of the track. The bar is then firmly jacked against the sides of the heading and drilling immediately begins on the top holes. Mucking out then continues during the drilling.

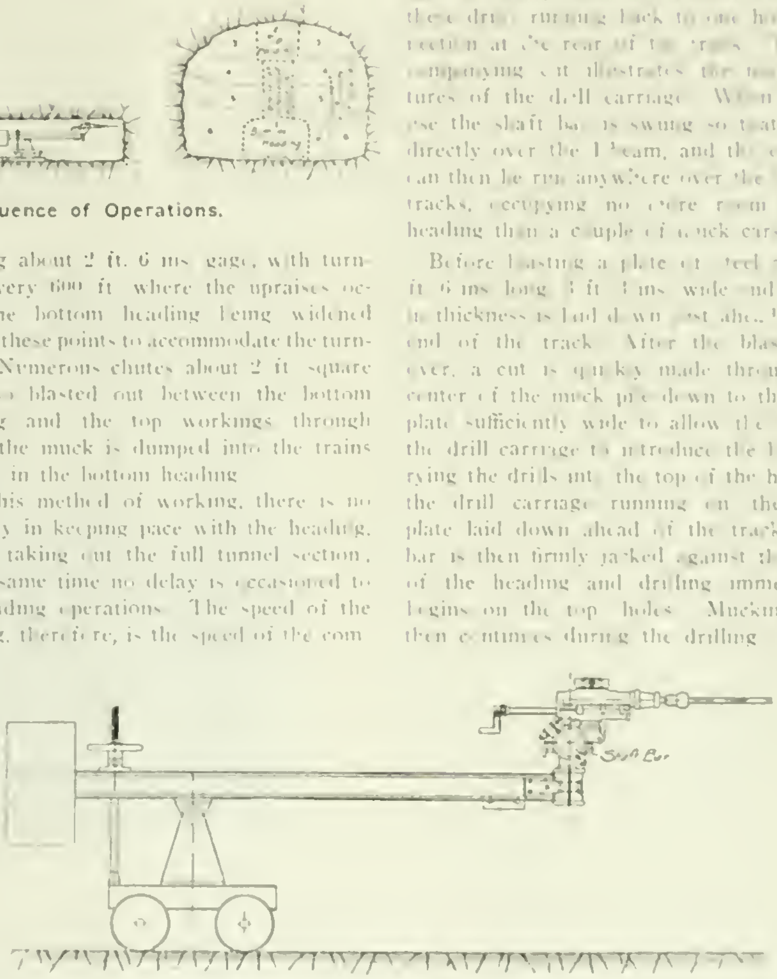

Fig. 2—Drill Carriage Used in Heading.

On account of the drills remaining on the drill carriage at all times with the air connections at the drill undisturbed, there is little chance for dirt and grit to get into the working parts of the drill and so impair its efficiency. The drills are of large size, having a piston diameter of 3⅝ ins. and are designated in the catalog of the manufacturer as "F 94."

There are from 2 to 4 holes drilled in each round for taking out the heading. These holes have a depth of 4 ft. and are 2 ins. in diameter at the bottom. They are arranged in four vertical rows, the two center rows corresponding to our center cut and two outer rows to the side round. The two center rows, however, are not pointed to form a V as is the custom in America, but are run in more nearly perpendicular to the face.

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*Reprinted from "Compressed Air," for February, 1909.

The rock so far encountered varies from granite to gneiss and is hard drilling. The compressed air for the drills is furnished by two Ingersoll-Rand compressors of the cross-compound two stage type, electrically driven and giving a pressure of from 90 to 100 pounds per sq. in. at the drills.

As soon as the round is all drilled, the drill carriage bearing the four drills is run back to the last turnout and blasting begins. Blasting at the Loetschberg tunnel is done by the fuse-and-cap method of exploding the charge. All of the holes are loaded and the fuses of all of them are ignited at the same time, but by a careful regulation of the length of these fuses a series of minor explosions occurs, so arranged that all of the center holes are exploded before the side holes.

More powder must necessarily be used in firing in this manner, but the advantages gained are as follows: less time is consumed in blasting; the rock is broken up more uniformly; and the effect of the blasting is less severe on the track than when the system of electrical firing is employed. There is one drawback to this method of firing by fuse-and-cap, viz., the danger arising from missed holes. An attempt is made to minimize this danger by employing two fuses in all holes except those at the bottom, where three fuses are introduced.

The work at the Loetschberg is carried on in three 8-hour shifts and each shift is expected to drill two rounds and to shoot twice, making about 7 ft. per shift, or 21 ft. per day. A liberal bonus is paid to the men for all speed made above a certain rate. The workmen are Italians, nearly all from the Northern provinces. The following table gives the approximate time for the various operations in the heading:

Setting up drill carriage in the heading	20 minutes
Drilling 12 or 14 holes	60 "
Removing drill carriage from the heading	20 "
Loading and firing the holes	30 "
Clearing out the smoke	20 "
Making cut through center of muck pile for carriage	90 "
Total	240 minutes or 4 hours

[There is no doubt that the Alpine tunnels have been driven at a much faster monthly rate than American tunnels, but the heading work in the European tunnel is nominally doubled, and American contractors and engineers will want to know the comparative costs of the two methods before changing from their own practice. However, some European methods and details can be adapted to our own practice.—Editors.]

Roads and Streets Section

Note: This Section is devoted to methods and costs of road and street construction. It will cover road building in all its details, the construction of pavements, sidewalks and gutters, the testing and use of paving materials and the machinery and tools used in road building and paving.

A Low Cost of Crushing Stone For Street Work.

BY W. A. GILLETTE.*

It may be of interest to builders of macadam roads or crushers of stone to know how cheaply the work can be done with a good small plant and when the supervision of the plant is intelligently administered. My experience in the above class of work leads me to believe that few plants of a capacity similar to the one which shows the output I will give below are giving such satisfactory results. The plant in question is owned by the City of Ventura, Cal., and the rock is used in the construction of Petrolithic macadam.

The engineering of the entire work has been done by J. B. Waud, and Mr. James M. Montgomery is the contractor. Mr. Montgomery has an exceptionally fine lot of stock, and the organization of his work is about as near perfection as it could be.

Stone Crushing Plant for Street Work, Ventura, Cal.

While looking over the work at Ventura the writer took occasion to make an inquiry regarding the cost per cubic yard for stone delivered on the street. This question was brought about from the fact that the work was being done at an exceptionally low cost, and it was hard to understand just why the cost was so much less than that of other similar construction.

I was told that the cost of the rock delivered on the street was something less than 50 cts. per cubic yard. It hardly seemed possible, when it was known that the average haul from the crusher to the work was about a mile, while the tough cobbles which are being crushed are gathered on the ocean beach and hauled in 1½-cu. yd. dump wagons to the crusher, a distance of about 1,500 ft., two teams with two wagons and drivers being used for this purpose.

Eight laborers are used to load the cobbles into the wagons; three men and the foreman do the work at the crusher and bins. The power to operate the crusher is electricity.

Five teams and drivers with dump wagons holding 2 cu. yds. each haul the crushed stone to the streets.

On this particular day all of the crushed stone was hauled ¾ mile and the screenings were hauled 1¼ miles. The wagons were heaped up so that they reached the street more than full. A good part of this haul was over very rough roads, so the rock was well settled in the wagon boxes.

The wages paid are as follows:

Two-horse team, wagon and driver, $4.50 for 9 hours.

Foreman, $4 per day.

Laborers, $2 per day.

The following is an itemized statement of the 9-hr. day's work:

One foreman, at $4.00 per day	$4.00
Eleven laborers, at $2.00 per day:	22.00
Two teams hauling cobbles to crusher, at $4.50 per day	9.00
Five teams hauling crushed stone to street, at $4.50 per day	22.50
Electric power, 67 k.w. hours., at 3 cts.	2.00
Engine oil	1.00
Total	$60.50

The total output for a large day's run was 132 cu. yds., as measured in the wagon boxes at a cost of $60.50, or 45.8 cts. per cu. yd. delivered on the street, exclusive of plant interest and depreciation. The plant cost $3,000. It consists of a No. 3 Austin gyratory crusher, having two 8½x 24-in. openings, driven by an electric motor.

Where the rock was crushed so that all of it would pass through a 2-in. ring the average output was 90 cu. yds. per 9-hr. day, or 67 cts. per cu. yd. for labor, hauling and power.

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*761 Pacific Electric Bldg., Los Angeles, Calif.

Cost Per Mile, Per Cent of Engineering Expenses and Bidding Prices on State Aid Roads in New Jersey in 1908.

During 1908 a total of 116.2[illegible] miles of improved roads were completed in New Jersey under the State Aid Law. The accompanying tabulation compiled from the report of the State Commissioner of Public Roads for 1908, shows the cost per mile, the per cent of engineering expenses, per cent supervisor's salary and bidding prices on the principal items in the construction of the roads. It will be noticed that the cost per mile of 6 in., 14 ft. macadam road varied from $6,748 to $13,616, the average being about $8,8[illegible]. This cost per mile includes excavation, drains, engineering expenses, supervisor's salary and extras. The supervisor, by the way, is an official appointed by the county to superintend, oversee and direct the work. The cost per mile for gravel roads varied from $2,116 to $5,354. The cost per mile for an 8 in., 16 ft. wide telford road varied from $7,551 to $19,397, this latter price being on a road less than a mile long and requiring over 21,000 cu. yds. of excavation. The average cost per mile for an 8 in., 16 ft. wide telford road was about $8,695.

The per cent of engineering expenses to total cost of road varied from 4.7 per cent to 1.3 per cent, the average being about 3.2 per cent. The per cent of supervisor's salary to total cost of road varied from 8.1 per cent to 1 per cent, the average being about 2.5 per cent.

The Theory of Economic Road and Street Design and Location.

(III.)

Cost of Feeding and Operating Teams.—The average work horse consumes about 30 lbs. of food per day during the working season, about half of which is usually hay and half grain. The following are typical daily food allowances for a work horse:

No. 1.

½ bu. (22 lbs.) oats.
18 lbs. hay.

No. 2.

⅓ bu. oats (11 lbs.).
1-6 bu. corn on ear (12 lbs.).
17 lbs. hay.

No. 3.

12 lbs. rolled barley.
1½ lbs. oats.
¼ lb. bran.
28 lbs. wheat hay.

Since the prices of hay, oats, etc., vary considerably in different parts of America, the engineer must make an estimate of the cost of feeding horses in the locality where the road is located. To do so he should ascertain the average market price of fodder in the given locality and deduct the cost of hauling it to market, in order to arrive at the value of the fodder on the farm. An example will illustrate the method of procedure:

	Per horse per day
½ bu. (22 lbs.) oats at [illegible] cts.	$0.17
18 lbs. hay at $10 ton	.09
1½ lbs. straw for bedding at $6 ton	.01
Shoeing	.0[illegible]
Total per day of working season	$0.[illegible]

When a horse is not working, hay and other [illegible] can be substituted for the grain, so that the per diem cost of feeding and maintenance becomes only a little more than half what it is during the working season. If the climate is such that the working season is 8½ months and the idle season 3½ months, or 260 and 105 days respectively, the total cost of maintenance for the year is:

260 days at [illegible] cts.	$[illegible]
105 days at 18 cts.	[illegible]
Total for 365 days	$[illegible]

As we have previously shown, the number of days actually worked is usually less than 200 per year in our Northern States. Hence, the cost of maintenance of a horse would be about 50 cts. per day under the conditions here assumed.

In addition to the item of feeding we have interest and depreciation. Assuming that a horse can be bought for $200, and that its depreciation is 10 per cent per annum, we have:

	Per year
$200 at 6 per cent interest	$12.[illegible]
200 at 10 per cent depreciation	20.[illegible]
Total for 365 days	$3[illegible]

If 200 days of the year are worked, then this cost of interest and depreciation amounts to 16 cts. per horse per day worked.

Summarizing, we have the cost of a team, driver, wagon and harness:

	Per day worked
Feed for 2 horses at [illegible] cts.	$1.[illegible]
Interest and depreciation, 2 horses at 16 cts.	[illegible]
Interest, depreciation and repairs on wagon and harness (20% of $[illegible])	.1[illegible]
Driver	1.6[illegible]
Total	$[illegible]

COST PER MILE, PER CENT OF ENGINEERING EXPENSES AND BIDDING PRICES ON STATE AID ROADS IN NEW JERSEY IN 1908.

Place. Kind.	Depth Ins.	Width Ft.	Length Miles.	Cost Per Mile.	Pct. Eng. Exp.	Pct. Supervisor Salary.	Earth Excavation Cu. yds.	Bid.	Gravel Cu. yds.	Bid.	Macadam Sq. yds.	Bid.	Telford Sq. yds.	Bid.
Hamilton—Gravel	[illegible]	16	14	$2,672[1]	4.6	2.1	1,07[illegible]	$0.[illegible]	[illegible]	$0.[illegible]				
Riverdale—Macadam	[illegible]	14	[illegible]	6,748	4.7	1.2	[illegible]	[illegible]			[illegible]	[illegible]		
Riverdale—Macadam	[illegible]	14	1.18	[illegible]	4.6	1.0	[illegible]	[illegible]			[illegible]	$[illegible]	[illegible]	$[illegible]
Hoboken—Macadam	[illegible]	[illegible]	[illegible]	10,188	2.9	7.0	[illegible]	[illegible]			[illegible]	[illegible]		
Woodcliff—Macadam	[illegible]	14	[illegible]	[illegible]	4.5	2.8	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]
Tabernacle—Gravel	[illegible]	[illegible]	[illegible]	[illegible]	4.6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]				
Lumberton—Macadam	[illegible]	14	.90	[illegible]	1.9	1.8	[illegible]	[illegible]			[illegible]	[illegible]		[illegible]
Delran—Macadam	8	14	1.12	[illegible]	1.9	2.8	[illegible]	[illegible]			[illegible]	[illegible]		
Pennsauken—Macadam	[illegible]	[illegible]	2.00	3,126	[illegible]	1.2					[illegible]	[illegible]		
Waterford—Gravel	[illegible]	14	[illegible]	[illegible]	1.3	8.1	[illegible]		[illegible]					
Upper—Gravel	8	14	1.40	[illegible]	[illegible]	1.8	[illegible]	[illegible]	[illegible]	[illegible]				
Caldwell—Telford	[illegible]	16	2.11	[illegible]	[illegible]	1.[illegible]	[illegible]	[illegible]					[illegible]	[illegible]
Caldwell—Telford	[illegible]	16	1.47	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]					[illegible]	[illegible]
Livingston—Telford	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]					[illegible]	[illegible]
Bloomfield—Telford	[illegible]	[illegible]	.88	[illegible]	[illegible]	1.5	[illegible]	[illegible]					[illegible]	[illegible]
Nutley—Telford	[illegible]	16	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]					[illegible]	[illegible]
Franklin—Gravel	[illegible]	14	[illegible]	[illegible]	4.6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]				
Readington—Macadam	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			[illegible]	[illegible]		
Princeton—Macadam	[illegible]	14	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]			[illegible]	[illegible]		
Hightstown—Macadam	[illegible]	14	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]			[illegible]	[illegible]		
West Windsor—Macadam	[illegible]	16	[illegible]	[illegible]		1.1	[illegible]	[illegible]			[illegible]	[illegible]		
Monroe—Gravel	[illegible]	[illegible]	[illegible]	2,95[illegible]		1.7	[illegible]	[illegible]	[illegible]	[illegible]				
Woodbridge—Macadam	[illegible]	14	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]			[illegible]	[illegible]		
Cranbury—Macadam	[illegible]	14	[illegible]	[illegible]		2.8	[illegible]	[illegible]			[illegible]	[illegible]		
North Brunswick—Macadam	[illegible]	16	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]			[illegible]	[illegible]		
Woodbridge—Macadam	8	14	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]			[illegible]	[illegible]		
Woodbridge—Macadam	[illegible]	14	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]			[illegible]	[illegible]		
Raritan—Macadam	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]			[illegible]	[illegible]		
Piscataway—Macadam	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]			[illegible]	[illegible]		
Monroe—Macadam	[illegible]	14	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]			[illegible]	[illegible]		
Howell—Gravel	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]				
Matawan—Macadam	[illegible]	14	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			[illegible]	[illegible]		
Rumson—Macadam	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		
Atlantic—Macadam	[illegible]	14	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			[illegible]	[illegible]		
Upper Freehold—Macadam	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			[illegible]	[illegible]		
Atlantic—Macadam	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			[illegible]	[illegible]		
Brick—Gravel	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]				
Manchester—Gravel	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]				
Pompton—Macadam	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.0	[illegible]	[illegible]			[illegible]	[illegible]		
West Milford—Macadam	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			[illegible]	[illegible]		
Alloway—Gravel	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]				
Franklin—Macadam	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			[illegible]	[illegible]		
Bernards—Macadam	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			[illegible]	[illegible]		
Linden—Macadam	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			[illegible]	[illegible]		
Union—Macadam	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			[illegible]	[illegible]		
Plainfield—Macadam	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			[illegible]			
[illegible]—Telford	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]					[illegible]	[illegible]
Harmony—Telford	[illegible]	[illegible]	[illegible]	8,911	1.4	1.2	30,72[illegible]	10					47,923	55

[1] Includes 25 acres of grubbing at $[illegible] per acre. [2] Rock excavation [illegible] cu. yds. at $1.[illegible]. [3] [illegible] ft. Telford [illegible] 17–17 ft. macadam 6 in. deep. [4] Tons. [5] and 1[illegible] in. [6] and embankment. [7] Compacted [illegible]. [8] Class A, there was also [illegible] cu. yds. of compacted gravel Class B at $1. [9] 9-in. center, [illegible] at points 7 ft. on each side of center line and [illegible] in. at points 12 ft. on each side of center line. [10] Liquid asphalt was applied at a cost of 8¼ cts., making total cost of macadam $[illegible] per sq. yd. [11] [illegible] in. in center, [illegible] in. at side. [12] Sq. yds. [13] 3 in. to 9 in. [14] Macadam with 14 ft. gravel wings, the gravel being 4 ins. deep. [15] In addition there was [illegible] cu. yds. of rock excavation at $1.60. [16] In addition there was 4,461 cu. yds. of rock excavation at $1.[illegible]. [17] [illegible] to [illegible] ins. [18] 16 ft. to [illegible] ft. [19] [illegible] in. and [illegible] in. [20] Also 5,827 sq. yds. 4 in. [illegible] at [illegible] cts. [21] 8 ins. and 12 ins. [22] [illegible] and 2[illegible] ft. [23] Also [illegible] cu. yds. [illegible] at $1.[illegible].

The driver is often paid a certain wage per month "and his board." In which case an estimate may be made to arrive at the real wage per day actually worked

The Value of Farm Team Time Is Independent of Season.—On page 16 of his "Roads and Pavements," Baker says:

> The great bulk of the hauling is done when the farmer has little or nothing to do. * * * and in this case the cost is merely nominal.

In this statement we find an example of sophistry that deserves careful consideration, for if team time is valueless after the crops are harvested, it is almost idle to attempt to apply any economic theory to road location and design. Indeed, we must then agree with Baker that "Any considerable expenditure for the improvement of rural highways cannot be justified on financial grounds alone." And we must also agree with Engineering News (Apr. 25, 1901, p. 305) that no community should issue bonds for road building, and that "state aid" in road building is an economic mistake.

Baker states that the great bulk of the hauling is done "when the farmer has little or nothing to do," and then the illogical inference follows that when the farmer does do something (hauling), the time spent in doing it has no measurable value. In brief, according to this view, any time spent in hauling is regarded as just so much time rescued from idleness. The *reductia ad absurdum* follows by asking why the spring plowing is not also just so much time likewise rescued from idleness, for then the reply is made that spring is a busy time for farm teams, whereas there is abundance of team time in the fall—more than the farmer knows what to do with. There is a subtle sophistry in this argument that has deceived, even so able an engineer as Baker. Let us, therefore, examine the argument with care.

It is assumed that for six or seven months on a farm all teams are kept quite busy plowing, harrowing, planting, cultivating and harvesting. Then, it is assumed, comes an "idle period" of several weeks or months that is much more than ample in which to do all the hauling, and that if 3 tons cannot be hauled per load, no real loss is incurred, for by making twice as many trips with 1½ tons per load the entire crop will be readily harvested anyway. The assumptions upon which this argument rests are fallacious in two respects: (1) Because the hauling time is not confined entirely to the fall season; (2) because even in the fall season the teams can be profitably employed at work on the farm.

The greatest single crop is grain, which is harvested in the fall, but the magnitude of other crops must not be overlooked. For every 100 bushels of wheat harvested in America, there are 40 bushels of potatoes, and potatoes are not a fall crop.

Baker has reasoned that the vegetable and fruit crop is relatively small, because the U. S. Census shows that less than 2 per cent of all the farmers specialize as gardeners, fruit growers, nurserymen, dairymen, vine growers and florists. He overlooks the fact that practically every farmer raises some vegetables and fruit, although the farmer does not specialize in that line, and is therefore not among the 2 per cent given in the Census. Baker's error is well brought out by the following facts:

The annual reports of the Interstate Commerce Commission give the number of tons of each class of produce hauled annually by the railways. According to the 1904 report, 30,500,000 tons of grain and 8,000,000 tons of vegetables and fruit were hauled by rail.

Clearly, the hauling of vegetables and fruits, which occurs at all seasons of the year, is even now a very large part of farm work, and where good roads are provided it becomes far larger. Therefore, the first assumption—that all hauling is done during the late fall season—is so far from the truth as to be entirely untenable.

The second assumption—that there is a special hauling season, or "idle period"—rests largely on the first assumption, but as a matter of fact there is no fall "idle season" when hauling is done.

At the very time that much of the hauling of fall crops to market is under way the teams could be profitably employed in many other ways, such, for example, as: Hauling and spreading fertilizer, fall plowing and harrowing, hauling public road materials and working on private farm roads, hauling materials for building permanent structures of concrete (fences, silos, buildings, etc.), hauling materials for tile drains, etc. The average American farm does not yield half as much wheat, for example, as it could produce if more labor were expended in preparing the soil by tillage and fertilizing. In England each acre sown to wheat average almost 30 bushels produced, or nearly twice the American average. This greater productiveness is due, in part, to greater labor expended in preparing and tilling the ground, and in part to more extensive use of fertilizers, both of which involve more team work.

With improved highways there is a greater demand for the teams, rather than less, for larger crops and bulkier crops can then be raised. Sugar beets, for example, yield 18 tons to the acre, and must be harvested in September. Speaking of the sugar beet crop, one authority says:

> "The inexpedience of withdrawing the horsepower of the farm from its other urgent work at the season most suitable for delivering these roots to the sugar maker, presents at present a serious hindrance to the cultivation of this crop."

Obviously the hindrance increases with the resistance opposed by poor highways.

There is not a period of the whole working season, whether it be in the early spring or the late fall, when farm teams cannot be put to useful work on any well-managed farm. Hence, it is evident that only false reasoning can lead to the conclusion that a team day at one time of the working season is worth less than at another time.

We reserve for later consideration the fact that a properly built highway greatly lengthens the working season, but our present object is to make it clear that the value of a team day spent in hauling at any season of the year is as great as when spent in plowing, harrowing, cultivating or harvesting. Sound reasoning can lead to no other conclusion, although a superficial and sophistical consideration of the subject may have deceived many farmers and a few engineers.

Cost of Hauling Per Ton-Mile.—Having estimated the cost per team per day worked, the next step is to estimate the number of ton-miles that a team will perform under the existing or under the assumed conditions.

On level, dry earth roads, 2 tons is a very heavy load for a team to haul, and 9 miles' travel with a load, returning 9 miles without a load, is a good day's work. This is equivalent to 18 ton-miles of useful hauling per day. More frequently the load is 1½ to 1¾ tons on a good earth road, and the day's work is 15 ton-miles.

On level, well-kept macadam, fully twice as great loads can be hauled as on earth. Both dynamometer tests and actual experience have proved this ratio of 2 to 1 to be about the average. The writer has never been able to get his teams to average more than 2 tons on good earth roads, but has had the same teams average 4 tons on good macadam, and even 5 tons where heavy horses and wagons with large wheels were used. Moreover, a greater distance can be traveled on a paved road, 20 to 24 miles being a fair day's work. Hence, 40 ton-miles can be secured on a level, paved road, the load being hauled only one way on the round trip. However, allowing for dirty, ill kept pavements, it is safe to say that only 30 ton-miles can be easily averaged.

Therefore, in the case of dry earth roads the cost is 20 cts. per ton-mile, when the wages of a team and driver are $3 a day; and on a paved road in poor condition the cost is 10 cts. per ton-mile for the bare cost of hauling, no allowance being made in either case for interest, repairs, depreciation, etc., on the road itself.

(To Be Continued.)

A special meeting of the members was held on April 21 at the house of the American Society of Civil Engineers in New York for the purpose of discussing various methods of constructing roads. The construction of macadam roads with a bituminous building material was discussed at some length. Following out this conference a resolution was passed at the session of the American Society of Civil Engineers on the evening of April 21, requesting the Board of Directors of the Society to appoint a special committee to report on bituminous materials for use in road construction and on standard methods for testing and using them.

The State Legislature of Pennsylvania has passed a bill providing for the construction of a highway from Philadelphia to Pittsburg by way of Harrisburg. The road is to have a 20 ft. carriageway of macadam and a complete width of 54 ft in cities and 60 ft. in the country. The route is to be selected by the Governor, State's Attorney General and the State Highway Commissioners.

In the concrete work at Gatun locks and spillway of the Isthmian Canal 3,750 barges of crushed rocks, each barge carrying 600 cu. yds., will be used. The sand required for this work would fill 1,875 barges of that capacity. Each barge is 150 ft. long and they are towed with a distance of 1,200 ft. between the tug and the first barge and between each of the barges.

The Brazilian government has had plans prepared for a dam at Japy, on the limits of the states of Parahyba do Norte and Rio Grande do Norte, to establish a reservoir for the use of the 100,000 people in that drought-stricken country. The dam will be constructed between two rocky mountains and the reservoir will extend back about 14 miles, having a capacity of over 132,000,000 gallons.

Roads are being made of sawdust in Florida. Two ridges of earth are thrown up with a road machine at the required width from each other and the space between is filled with sawdust. This is followed with a smaller machine which plows up and mixes the earth with the sawdust The roads are stated to cost $297 per mile.

The gold production of Australasia for 1908 amounted to 3,552,325 fine ounces.

Unclassified and General Articles

Note: This section is devoted to methods and cost articles on construction work not properly coming under any of the preceding classifications.

Methods of Field Work in Connection With Caisson Sinking.

BY [illegible] VAN DE [illegible].*

This article will take up the field work done in connection with the sinking of the caisson of Pier 2 of the Kaw River bridge, Sixth Street viaduct, in Kansas City, Mo. Waddell & Hedrick were the consulting engineers, L. B. Howard was resident engineer, and the writer principal assistant engineer. The substructure work was done by [illegible] & McMurray, contractors.

Methods of triangulation for pier location and descriptions of caissons in general can be found in text books and engineering literature. Therefore, in this article these subjects will be touched upon only in a general way, but the work subsequent to the triangulation will be treated more fully.

Triangulation.—The main base line was laid on the adjacent Chicago Great Western Railroad bridge. The line was run on the top of the ties parallel to and just outside of the track and extended back to intersect with the bridge tangent. In this line a hole was punched in the top flange of the end floor beam at the fixed end of the first and third span of the bridge. For the sake of convenience call the intersection of base and line and bridge tangent *A*, the first punch hole *B* and the second punch hole *C*. Distances *AB* and *BC* were measured with base line accuracy and the angle at *A* determined. The distance *AB* was found to be [illegible] ft and *BC* [illegible] ft.

The Kaw bridge consisted of two spans, each of about 300 ft length. Pier 1 and Pier 3 were on the east and west shores of the river, and Pier 2 in the middle of the stream. The angles to be turned off from the base line at points *B* and *C* to form an intersection with the bridge tangent at the desired pier centers were calculated. Then with the transit set over *B* and *C* in turn, these calculated angles were accurately turned off and permanent foresights put up and firmly secured. Probably the most accurate way in which to establish such a reference line is as follows: Suppose transit to be set up at *B*, sight on *C* and turn off the angle calculated; mark the line on a board securely fastened with its plane perpendicular to the reference line. Call this point *D*. With transit still at *B* read the angle *CBD* very accurately, in such a way as to eliminate as much as possible all errors. The angle *CBD* as now determined will be slightly greater or less than the required angle. Move transit to *C* and read angle *BCD*; calculate the length of line *BD*. Knowing the length *BD* and the error in the angle *CBD* as previously determined, it is then easy to calculate the amount that the mark on the board should be moved to correct the error in the angle. A target can then be painted on the board with a distinguishing letter or number which can be seen with the transit at point *B*. Of course, it is not always possible to have a board target, nor is it always best, but the above method can be used, whatever kind of monument is used for permanent foresight. It is convenient to have permanent foresights which can be easily seen from the transit, as much time is saved if it is not necessary to send a man across the river with a flag pole each time a foresight is needed. On the west side of the Kaw River a second base line was laid off by which a check on the work from the main base line was secured. In general a bridge is not the best place on which to establish a base line, due to vibration from trains passing, but in this case it was the best available, and good intersections were secured with the bridge tangent for location of piers.

The Caisson.—The caisson was simple in form. It might be described as a big parallelopipe formed by building one box on top of another. The bottom box was open at the bottom, had a roof of solid timber 6 ft thick and sides of box were 3 ft thick. The bottom edge was shod with a steel cutting edge. The inside of this box is what is called the working chamber. This box was kept from being distorted by wooden struts and 1½-in. adjustable rods inside. Two horizontal rows of 12x12-in. wooden struts were used, distance between two struts in each row being about 9 ft 6 ins. One row was just below the ceiling of the working chamber and the other row about 1 ft 10 ins. above the cutting edge. Parallel to and close to each strut in the bottom row 1½-in. adjustable rods extended through the caisson from outside to outside of the caisson walls. The bottom box was made water tight by thorough calking. The top box was open at the top and bottom, the sides consisting of 12x12-in. timbers well drifted together and cross braced with timber struts. Extending up from the working chamber through the 6-ft roof were the supply shafts, mud lifts, air pipes, water pipes, and main shaft, through which the work in the working chamber is carried on. The caisson was 22 ft wide, 56 ft long, out to out, built of long leaf southern yellow pine. The outside of both boxes was covered with 2-in. lumber placed with long dimension vertical. The distance from cutting edge to top of 6-ft roof of working chamber was 13½ ft. The construction of the caisson was closely watched in order that the plans and specifications be complied with. The caisson was built on shore to the top of the bottom box, all pipes, etc., being in place, and was afterward launched and floated to position.

False Bottom.—It might be well at this point to show the unique method resorted to to make possible the floating of the caisson. It was, as above stated, 22 ft wide and 56 ft long, the distance from the cutting edge to top of roof of working chamber being 13½ ft, roof 6 ft thick, and sides of working chamber 3 ft thick. The writer cannot state just what the weight of the timber was per cubic foot, nor the weight of the metal in shafts, etc. The volume of the timber was about 10,000 cu ft. Assuming the timber to weigh 40 lbs per cu ft, then the timber would weigh 400,000 lbs. The steel cutting edge, bolts, etc., assume as 20,000 lbs, bringing total weight up to 420,000 lbs. Taking weight of 1 cu ft of water as 62½ lbs, it is seen that 6,720 cu ft of water will be displaced or [illegible] cu ft of timber will be above the water level.

[illegible] $2\frac{2}{3}$ ft $13\frac{1}{2}$ ft — $2\frac{2}{3}$ = [illegible] 10.89 = 22.8 in.

which would be the depth of the cutting edge below the surface of the water. The river, however, was not less deep than this, especially near the shore. The following method was then resorted to. A false floor was put in the bottom of the working chamber on the bottom side of the lower row of horizontal struts. The bottoms of the struts were 1 ft 10 ins. above the cutting edge. A floor of 2-in. lumber was nailed to the struts, the floor being planked with calking grooves and the whole well calked so as to make the working chamber impervious to the water at the bottom.

Now the depth of the cutting edge below the surface of water, when caisson was floated, would be about 1 ft 8 ins. plus 6,270 ÷ 22×56 ft, or about 7 ft. The depth of the river permitted the caisson to be floated to its position under these conditions. After the caisson was in position the false floor was removed and caisson allowed to settle.

While the construction of the caisson on shore was going on, a tramway was built parallel to the bridge tangent from the shore out to the pier site. This tramway was so located that it would not interfere with the subsequent work on the bridge, such as the false work for the superstructure. This tramway was used to carry concrete (all of which was mixed on shore), timber and other materials out to the caisson after it had been floated to position. The tramway also served to carry the water and air pipes which extended from the machines on shore to the caisson. A building housed the pumps and air compressors, from which the water and air were pumped to the working chamber.

As soon as the tramway was carried out far enough a direct measurement was made on it and the transverse center line of pier marked. Then the places to drive the guide piles were located and marked for the contractor. The guide piles were used to keep the caisson guided in approximately correct position until it had been settled into the river bed some distance. All the pile driving was done from a barge. The illustration shows tramway, guide piles and caisson ready for launching.

As soon as the guide piles were driven and capped a temporary platform was built on these. This platform served as a plane on which to locate the center of pier from the base lines and bridge tangent. The bridge tangent and the lines turned off from points *B* and *C* on the base line should have intersected at a point if the triangulation work had been done correctly. The error was within the limits of accuracy set for this class of work, being inappreciable. Therefore the reference lines were not changed. A fairly good check on the triangulation work was secured by direct measurement along the tramway.

Before the caisson was launched a heavy spike was driven at exactly 10 ft above the cutting edge at each of the four corners of the caisson. Each heavy spike had its head cut off so as to allow a level rod to rest upon its end edge. The caisson was then launched and floated to position between the guide piles.

After the sinking was well started the routine work of the engineer, in addition to inspecting concrete, etc., consisted of keeping a record of the position of the cutting edge. As the caisson sank, new heavy spikes were put in higher up at exact distances above those last driven, so that the true elevation of the cutting edge could always be ascertained. In putting in such new points the measurements were always made accurately, and a record of the distance above the cutting edge kept.

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To get the data for calculation of position of cutting edge, the proceeding was as follows: On the caisson the center of finished pier was located by intersection of bridge tangent and one of the reference lines. The transit was set over this point and a right angle turned from the bridge tangent. On the outside edges of the caisson were marked the transverse and longitudinal center lines of the pier. The distances from each of these points to the two adjacent corners of the caisson were measured and noted. This showed how far the center of each side of the caisson at the top was off from the center lines of finished pier. Immediately a level was set up on the caisson and a long backsight taken on a bench mark on the shore and careful foresight taken on each of the four boat spikes. The location of the cutting edge could be fully determined from the above data.

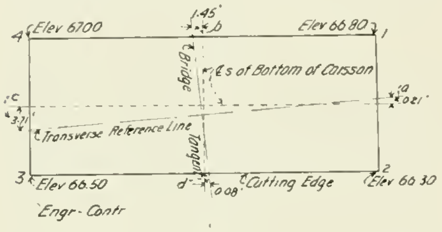

Fig. 1.

The following is an ideal example: Suppose that the top of caisson is out of position, as shown in Fig. 1, and that the elevation on the spikes at the four corners are as follows:

Corner 4 elev. = 97.00.
Corner 3 elev. = 96.50.
Corner 1 elev. = 96.80.
Corner 2 elev. = 96.30.

Further, suppose the distance from boat spikes to cutting edge is 30 ft. and that the top of caisson is 5 ft. above the boat spikes. The caisson is 22 ft. wide and 56 ft. long. By the relation of similar triangles it is easy to calculate the position of cutting edge shown in Fig. 4. Figs. 2 and 3 explain themselves, being intermediate steps in the calculation. In Fig. 2, d' is given as 0.08 ft. By similar triangles

$$\frac{0.2}{56} = \frac{d'}{35} \text{ or } d' = .012 \text{ ft.}$$

but d' must be corrected, as is obvious from Fig. 4, by the amount $\frac{1.54}{22} \times 0.5$ or -0.04 ft., as the caisson is tilted two ways. This makes $d' = 0.08$ ft. The same method is used in finding the position of the other three sides. The hypothenuse is used in the relation instead of the leg of the triangle, but this does not introduce any appreciable error

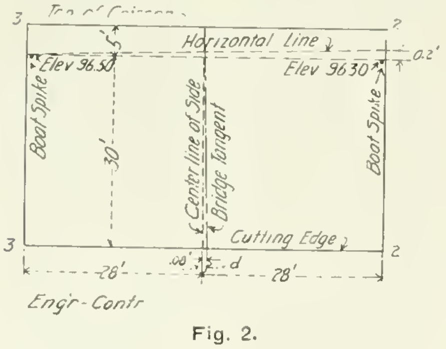

Fig. 2.

The results shown in Figs. 1 and 4 are what the contractor needs. The sketches 1 and 4 and a short letter of instruction—if needed—are given to him. A copy of sketches and letter should be kept by the engineers for several reasons. Generally, instead of giving elevations as shown on Fig. 4, the amount of each of three corners above the fourth low corner is given in feet and inches.

The instrument work was done immediately after the blowing or settling of the caisson, so that there was no movement of the caisson during the time the instrument work was being carried on. As the caisson neared the bedrock the position of the cutting edge was found after each settling. Throughout the work the caisson was kept in as correct a position as possible. As the caisson neared bedrock every effort was used to keep it where it should be.

Inspection in Working Chamber.—Before bedrock was reached there was very little necessity for the engineer to be in the working chamber. Occasionally he had to go down to help the contractor devise some scheme to shift the caisson when it went so far out of true position as to become alarming. When bedrock—soapstone in this case—was reached, the stone was leveled off somewhat, and a trench 18 ins. wide at the bottom, 3 ft. wide at the top, and about 18 to 24 ins. deep was cut out along the sides of the working chamber just inside the cutting edge. This was done to guard against slipping of the caisson and in case the gravel overlaying the soapstone was scoured out.

Filling the Working Chamber.—After the foundation had been prepared the work of filling up the working chamber and the several shafts was started. During this work constant inspection was maintained, only those inspectors being used who could stand the air pressure. The inspectors took turns. Some inspected the concrete mixing on shore and the others the placing of the concrete in the chamber. The concrete was mixed quite dry and let down through the material shafts into the working chamber. It was deposited at the ends of the working chamber first and well tamped. The chamber was gradually filled, that part nearest the main shaft being done last, necessarily. After the working chamber was completely filled the shafts were entirely filled with concrete.

In General—In the case of an octagonal or circular pier the same scheme as herein outlined can be used in locating the cutting edge. In general, it may be said that in case of shallow rivers a tramway is built, and the concrete materials are mixed on shore and carried out on the tramway, while in the case of a deep river the concrete aggregates are mixed on barges anchored near to the caisson and all work handled from the barges.

Often, in order to save timber and concrete, the crib work is stopped and the shaft of the pier commenced on the crib before the cutting edge reaches bedrock. In such a case extreme care should be exercised in giving the center lines for bottom of shaft that these lines will coincide with the correct center lines of the pier when the caisson comes to rest on its foundation. This method should be used only when the cutting edge is but a short distance from bedrock, as the movements of a caisson will not always be just as they are calculated. Also the shaft should be made somewhat larger all around than the plan size, so that when bedrock is reached a little shifting of the remainder of the shaft can be done if found necessary. The practice of starting the shaft on the crib when the caisson is any considerable distance above the foundation is a bad one, as the actual direction of movement of the caisson may be quite different from what the engineer supposed it would be. Under such conditions the top of the shaft already built might be so far out of true position when the caisson reached bedrock as to prove disastrous. On the Kaw River bridge the crib work was stopped and the shaft started when the cutting edge was a few feet above bedrock in order to save concrete. The caisson acted just as anticipated and the top of the shaft was very little out of true position. The advice of the superintendent as to the future movement of the caisson and crib will be valuable if he is a man of considerable experience in pneumatic caisson work.

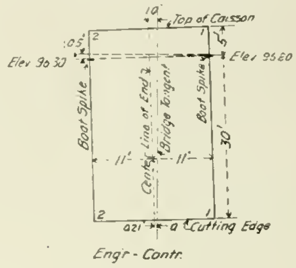

Fig. 3.

Pressure in Working Chamber.—A few words might be said as to variation of the pressure in the working chamber. When blowing a caisson to settle it, the amount the water rises in the chamber depends on the character of the material the cutting edge is in. For instance, if it is in stiff clay, the caisson can be blown and settled 2 or 3 ft. without any water apparent at all, while if it is in soft material or sand, the water will come up appreciably. Mr. E. E. Howard informed the writer that he had been in caissons where on settling the water came up 2 ft. above the cutting edge. Of course, the pressure varies somewhat in the proportion of the hydrostatic pressure; that is, 0.434 h pounds per square inch, where h is the depth in feet below the water surface. However, it will not always hold to this exact amount. In fact, it rarely does, depending on the class of material being excavated. In stiff clay the pressure can be run down considerably below the theoretic amount, or run up above this amount without much leakage in either case. To hasten the work of getting out the material the pressure in clay is often run up considerably. In sand or soft material, on the other hand, as soon as the pressure is brought up very much above the hydrostatic pressure, air is bound to be forced out around the cutting edge, as is shown by the bubbling of the water at the surface outside.

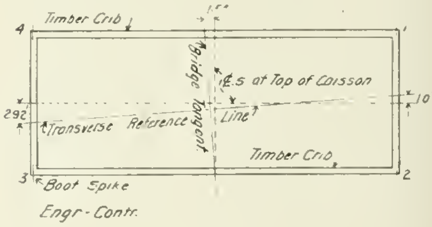

Fig. 4.

In general, it might be said that in clay the pressure is kept a little below, and in sand or soft material, a little above the true hydrostatic pressure.

Methods and Cost of Constructing a Roundhouse and Engine Terminal Facilities at Decatur, Ill., Wabash R. R.*

BY A. O. CUNNINGHAM†

The Wabash R. R. Co. has [illegible] [illegible] a large amount of money in improving engine facilities at Decatur, Ill. This plant is situated very nearly half way between St. Louis and Chicago and is at the junction of the Springfield and Decatur divisions of the Wabash R. R. The Decatur Division extends from St. Louis to Chicago, from Bement to Tilton, and from Bement to [illegible], and comprises [illegible] miles. All trains from St. Louis for points north and east pass through Decatur so that this engine terminal is the most important on the system. There are approximately 100 engines [illegible] [illegible] per day.

Previously to these improvements, engines were housed in an old and dilapidated building which had been in service over 25 years at the time when the improvements were commenced. The old engine house was too short for up-to-date engines and the stalls [illegible] had been lengthened out to properly house the new engines. These extensions were generally made of wood. A new turntable was installed about six years ago, designed to fit the old foundations of the older turntable, and consequently its depth was not sufficient, with the result that there was usually too much deflection, requiring more power to turn it than should have been necessary. It was operated by a 9 hp. gasoline motor and did the work fairly satisfactorily.

Coal for the engines was obtained from a coal [illegible] in the Decatur yard which had a few [illegible] to accommodate the engines. A [illegible] [illegible] [illegible] was [illegible] to the old engine house [illegible] [illegible] of the [illegible] engines, and [illegible] [illegible] [illegible] for [illegible] [illegible] [illegible] [illegible] from the [illegible] [illegible] the [illegible] of the [illegible]. Because of these poor facilities, together with [illegible] [illegible] and [illegible] [illegible], the cost of handling engines was exceedingly great.

About two years ago improvements were started to remedy these defects and to lessen this cost. The first structure which it was necessary to build was the coaling chute, as the coal yard which formerly supplied the engines had practically given out. This coaling plant was constructed of timber on concrete foundations. It was designed with an elevated pocket that would hold 200 tons of coal, from which the engines could be coaled from ordinary

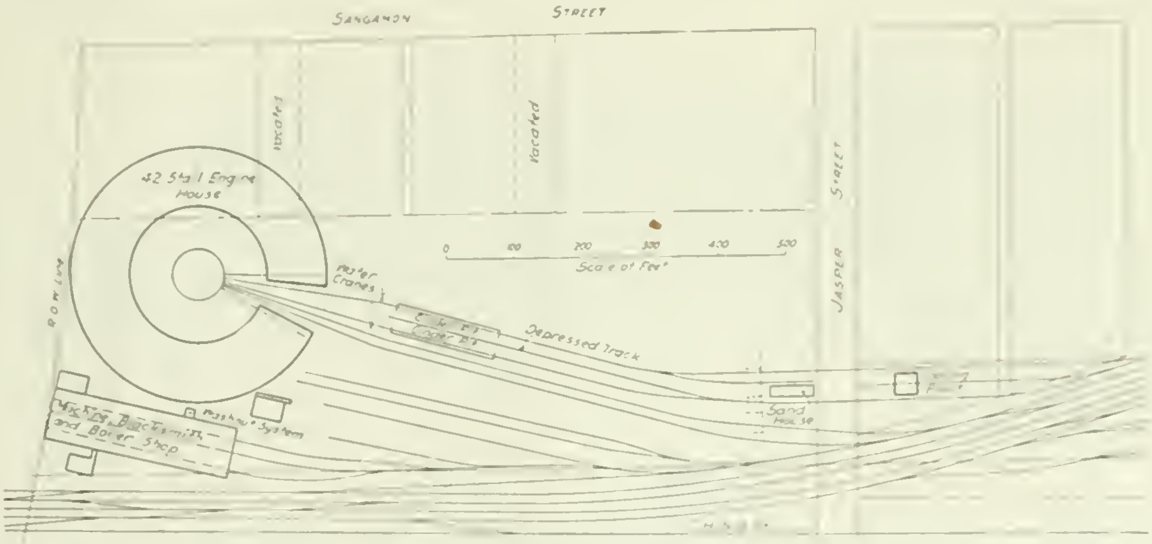

Fig. 1—Lay-Out of Engine Terminals Wabash R. R. at Decatur, Ill.

[illegible] aprons, and was constructed by the Fairbanks Morse Co. Coal is brought to the chute in bottom dump cars and is dumped into a concrete hopper beneath the track. From the hopper it is elevated under control of the operator by [illegible] into [illegible] buckets through [illegible] in each of the two side walls of the tower to hopper. There are two of these buckets, each with sufficient capacity for holding a ton of coal, and as one bucket is hoisted the other is lowered. [illegible] [illegible] [illegible] [illegible] the two dumps automatically into the receiving bin. The whole plant is operated by an electric motor controlled by one man, but two men in addition are necessary to empty the coal from the bottom dump cars. It requires about 2½ hours to fill the bin provided no engines are taking coal during that time. But since engines are continually being coaled, it is necessary to operate the plant about 10 hours, the capacity of the bin being sufficient to take care of the coal required [illegible] [illegible] [illegible] 11 hours. At the time of [illegible] coal through [illegible] [illegible] plant [illegible] [illegible] [illegible] [illegible] [illegible] there [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]. The cost of labor, superintendence, etc., for operating for a period of 10 hours is $7. To this should be added depreciation charges, interest on the investment and cost of maintenance. The cost of the foundations and concrete work was $1,2[illegible] and for the superstructure above foundation $7,500, including the motors and machinery, making the total $8,7[illegible]. The interest charge on this investment at 5 per cent would be $4[illegible]. The depreciation should vary according to the length of time the plant is in service; nothing should be charged for this for the first ten years, but thereafter a charge of 5 per cent per annum should be made. It is [illegible] that the life of the plant is [illegible] to be 30 years. Maintenance charges will vary [illegible] and will increase as the plant grows older. 1 per cent per annum should take care of this. Assuming these figures correct, then the cost of operating the plant will be $3,1[illegible] per year. As there go, on an average, [illegible] tons of coal per day handled by the plant, the cost of handling coal will be slightly less than [illegible] cts. per ton.

It would be noted that no attempt has been made [illegible] [illegible] [illegible] for [illegible] coal [illegible] from the storage [illegible] to the depressed [illegible]. Such a [illegible] would be [illegible], [illegible] would not be [illegible] in this territory, because the [illegible] [illegible] at may be [illegible] [illegible] yard [illegible] which [illegible] [illegible] to take water in close proximity to the coal chute, and [illegible] this would [illegible] [illegible] [illegible] [illegible]. Since the [illegible] [illegible] [illegible] the coal chute it would be necessary to make proper allowance for the small amount of work done by the switch engines in performing this service.

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*Paper read May 2[illegible], 1906, before the Engineers' Club of St. Louis and published in the "Journal of the Association of Engineering Societies" for December, 190[illegible].

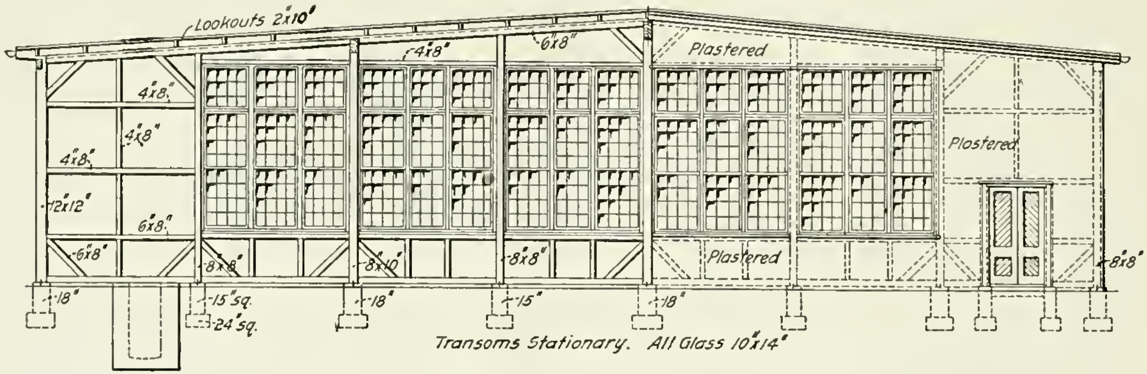
†Chief Engineer, Wabash R. R., St. Louis, Mo.

Usually in connection with a coaling plant there is installed a sand house for receiving and drying sand for locomotives, but as the sand house used with the old facilities was in good repair, it was moved to a new location and used in conjunction with the new facilities. It consists of a long oblong building with a tower at one end. The sand is brought in cars and unloaded by hand into the building, at one end of which is a sand-drying device, which is nothing more than a cast-iron barrel-shaped stove around which is fastened a very fine funnel-shaped screen. The sand is placed between the stove and the screen and on drying falls through the latter, after which it is shoveled into a hopper and driven by compressed air into the tower of the building. It falls by gravity from this tower through pipes which may be connected with the locomotives.

The next improvement was the construction of a new, up-to-date roundhouse with 42 stalls, new turntable and cinder pit, with all modern facilities for doing work cheaply. It might be claimed that the superstructure of this engine house is not up-to-date on account of its framework being of wood. However, there is but one other kind of material that could be used in place of wood that would last any longer, and that is reinforced concrete. We all know that steel is soon rusted out where there is an abundance of smoke; therefore, steel unless properly protected should not be used in a roundhouse. Reinforced concrete construction is expensive, and, in the writer's opinion, not necessary because properly constructed engine houses with large timbers will last from 25 to 30 years, as smoke seems to preserve the timber. It is a waste of money to build such structures on Western railroads with the idea of making them everlasting, because these railroads are continually changing in their ownership and extending their lines, making it often advisable to change the location of their engine terminals and shops; and is it not also possible that railroads will be using electric motive power within a few years, requiring the reconstruction of engine shops and terminals? The only good argument for the use of reinforced concrete in buildings of this nature is the fact that it is fireproof; but there is so little danger of fire with a properly constructed engine house with heavy timbers that this argument need not be considered. In planning the construction of the new engine house, there were several things to be considered. First, it was necessary to do the work without interfering with the old facilities so that engines could be handled without loss of time. Further, there were three buildings in close proximity to the proposed site of the engine house (Fig. 1) which would work in with the arrangements of the new facilities. One was a boiler house about six years old, which could be used for heating purposes; another was a building of wooden construction, which could be turned into a machine shop, and the third was a two-story building which could be used advantageously for an office. It was finally found practical to so place the new engine house that these three old buildings could be utilized, and at the same time the new construction work could be carried on without interfering with the old facilities. As the Wabash had a year previously constructed large car shops in East Decatur, of which the operating power was electricity, and since there was ample current to spare from this plant, it was decided to use electricity to operate all the machinery and to provide light for the new terminal facilities.

The roundhouse is a complete circle, except for an opening sufficiently large to accommodate outbound and inbound tracks leading to the turntable. The house is of heavy mill construction, the timbers being of long leaf yellow pine. The construction is of the simplest kind, with posts between the stalls carrying the roof so as to cheapen its cost. The roof beams supported by the posts run crosswise of the engine pits, and the joists, to which the roof sheathing is nailed, rests on the beams and run lengthwise of the pits. This enables the smoke from the engines entering or leaving the house to follow the joists and find exit at the peak of the roof, at which point there is provided a ventilator over each stall, each ventilator being accommodated with a pivoted shutter, which can be opened or closed by a simple mechanism worked from the floor.

The walls of the building (Figs. 2 and 3) are constructed of wooden girts of the same width as the posts, and supported between them, to which is attached expanded metal, both on the inner surface and outer surface of the girts. The expanded metal on the outer surface is plastered on both sides with a mixture of Portland cement, lime and sand, and cocoanut fiber. The expanded metal on the inner surface is, of course, only coated on one side with the same kind of plaster. This construction provides a wall with a hollow space of air between, so that dampness cannot penetrate to the inner surface. The air space forms a good insulator to keep the building warm in winter and cool in summer. The plaster applied to these walls consists of 1 bbl. of lime mixed with 15 bbls. of sand and 4 lbs. of cocoanut fiber, the whole being mixed thoroughly with water and allowed to stand for at least two weeks so as to give the lime time enough to thoroughly slack. One part of Portland cement is added to three parts of this mixture, with enough water added to make a plastic mortar. This is applied to the expanded metal and allowed to harden. This is called a scratch coat. On this coat is plastered another layer of mortar, composed of 3 parts of sand to 1 part of cement. The plaster on the expanded metal on the outer surface of the house is 1½ ins. thick, and that on the inner surface about ¾ in. thick. This hollow wall extends completely around the outside of the house, and from the ground to a height of 5 ft. The exterior face of the wall is painted with a waterproofing compound. On this wall is placed a continuous line of windows, which extend to the underside of the eaves of the building, thus providing plenty of light, which is very essential in such buildings. The cost of a wall of this description is slightly less than brick, but a saving is made because brickwork requires foundations to support it,



Showing Framing. Showing Finish.

Fig. 2—End Elevation of Roundhouse.

while this construction required all the [illegible] necessary to support the posts. Also lintels are required over openings in brickwork, and some are required in the head of a wall. A further advantage in this construction is that a continuous line of windows may be used while with brickwork this is not possible on account of the pilasters. The windows are made so that the two lower sashes are hung together with copper chains over pulleys; thus when one is raised the other is lowered; consequently they are counterbalanced without going to the expense of providing box frames with counterweights.

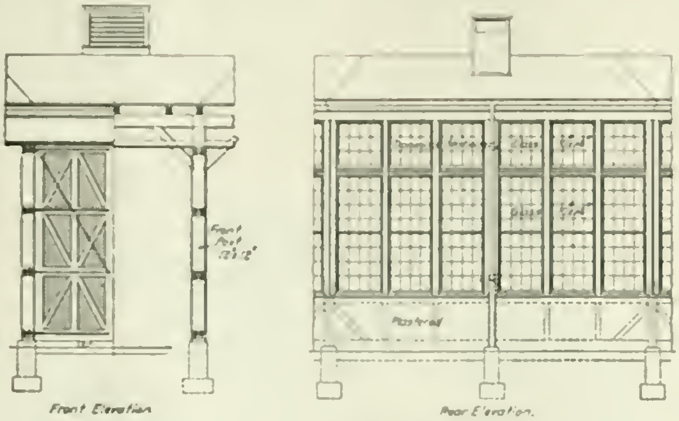


Fig. 3—Front and Rear Elevations of Roundhouse.

The doors in the front of the building are made of yellow pine, substantially built and with no glass in them. They are provided with convenient hand latching devices, which lock them at the top and bottom when they are closed. To keep them in an open position, when necessary, there are provided pieces of old rail set in a vertical position in concrete and placed radially with the door posts on the outside of the building, to which are attached hooks which engage in eyes in the door to hold them securely so as to prevent damage being done to them from high winds and by locomotives entering and leaving the house. At certain intervals the large doors are provided with smaller ones, so that the house can be entered [illegible] at different points.

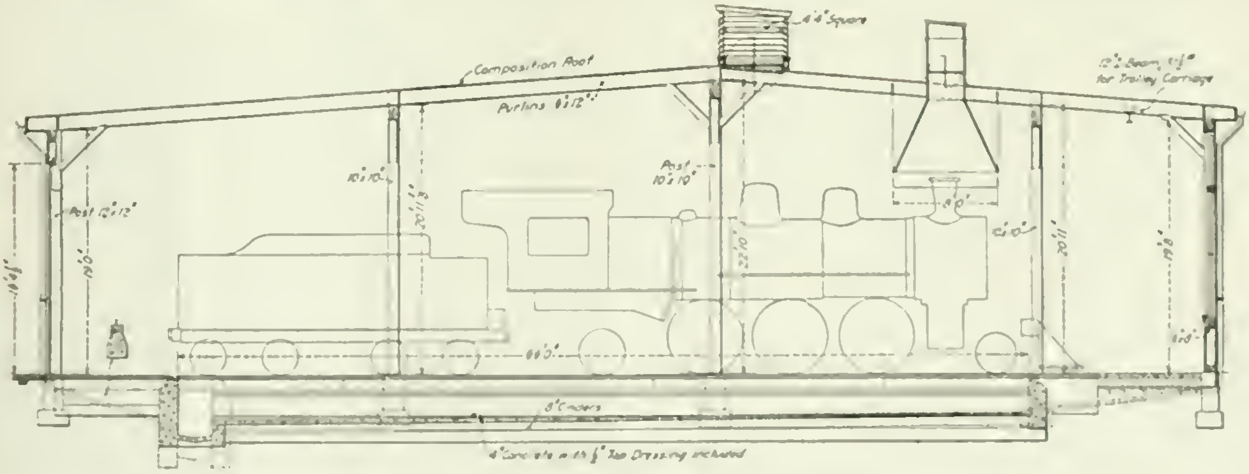


Fig. 4—Transverse Section of Roundhouse.

The pits are of concrete and constructed so that in jacking up engines in order to remove the parts, the jacks rest on projections built on the walls of the pit; otherwise the floor of the house would suffer.

On account of the liability of concrete in proximity to the rails to break up, due probably to the oil which drips from the engines, it was decided to fasten treated timbers on the walls of the pits and to spike the rails to them. It was estimated that the life of these timbers would be equal to that of the house, and, therefore, would be quite satisfactory.

Concrete foundations are provided to support the timbers on which the rails rest at the ends of the pits, and from the pits to the doors of the house, from which point to the turntable the rails are carried on ordinary track ties, under which cinder ballast is placed.

The pits open into a concrete duct, built entirely around the inner side of the front of the house. This duct serves the two purposes of draining the pits and carrying the heating mains, and is covered with checkered wrought iron plates. In a convenient location of the house are constructed two drop pits and two [illegible] track wheel pits. Over these pits the roof is arranged [illegible] the posts being removed so as to allow engine wheels to be moved around the pits and raised [illegible] provided for them. One of these tracks connects directly with the machine shop.

The floor of the roundhouse is of concrete built similarly to a sidewalk and placed on cinders. It is laid out in squares of about 5 ft. to the side, so if any square gets broken as it is liable to be on account of the heavy pieces handled in a house of this description, it can be repaired at small cost.

The foundations carrying the posts are of concrete and are entirely separate from the floor, so if any settle the floor will not be disturbed.

On the roof sheathing is laid a built up roof of 5-ply tar and crushed limestone. The crushed limestone not only adds weight to hold the built up roof in place, but, being white in color, helps to protect the tar from the rays of the sun. The cost of this roof covering in place was about the same as that of a prepared roofing.

One of the essential parts of an engine house is the smoke jack to carry off the smoke from the engines standing in the house. So far, a satisfactory one has not been designed. Ordinarily, smokejacks are made of cast iron, which corrodes in a short time. Some of asbestos board have been tried, but they have not proved satisfactory. On this account it was decided to try a smokejack made of expanded metal (Fig. 5) attached to an iron frame plastered over with a mixture similar to that used on the walls of the building. The plaster covers up the ironwork entirely, and it is expected that a jack of this make will last a good deal longer than one of cast iron, with the advantage that it can be readily patched if it should become necessary. These jacks have now been in use for six months with no apparent damage to them. The only objection to them is their weight. If constructed with plaster 1¼ ins. in thickness, they should weigh practically the same as cast iron. The style of jack best suited for a roundhouse is an inverted hopper leading to a chimney, the bottom opening of the hopper being about 3 ft. wide by 8 ft. long, to permit of the movement of engines two or three feet longitudinally from their proper central position, in order to get at their valves, etc.

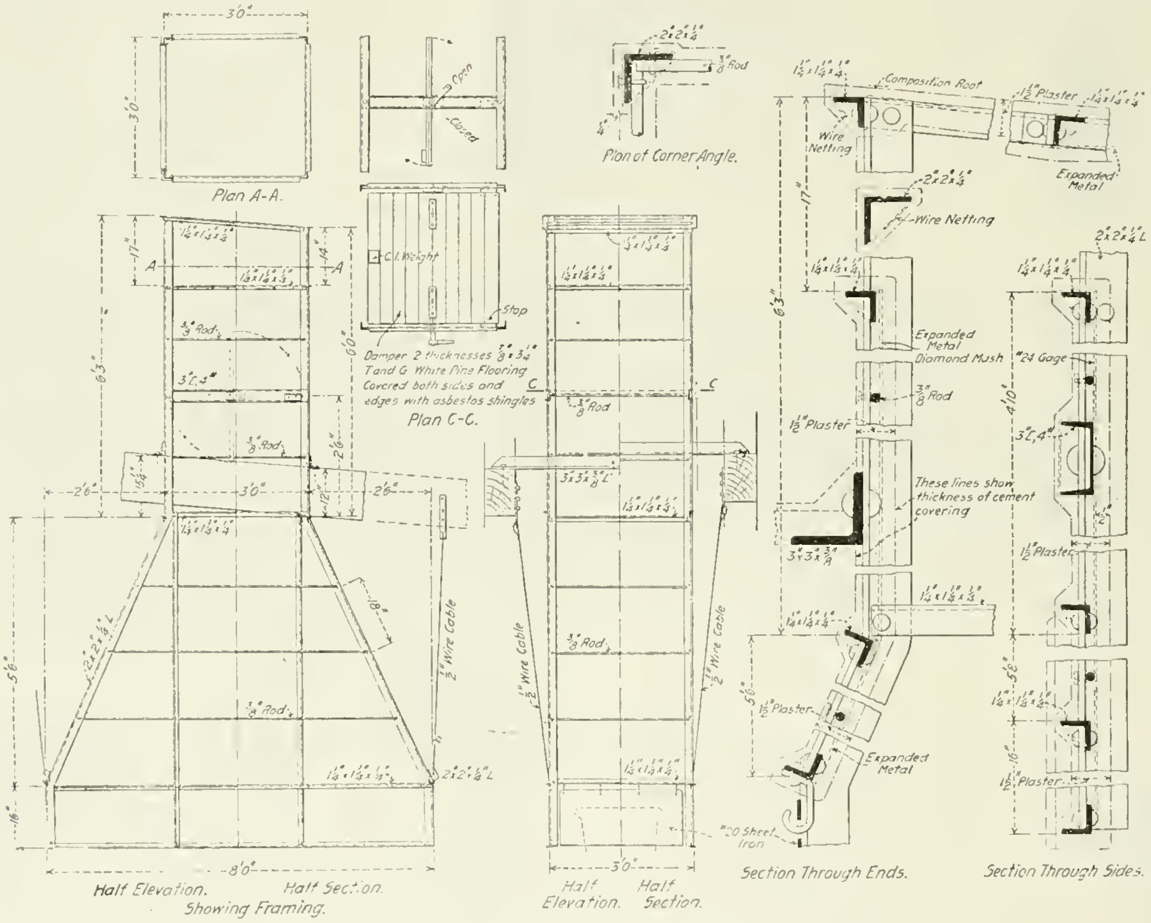


Fig. 5—Details of Expanded Metal and Concrete Smoke Jack.

In order to facilitate the handling of material from the roundhouse to the machine shop, a telpher hoist has been provided, running on an I-beam track, supported to the roof joists near the back of the house. This hoist is operated by electricity and will lift a load of two tons and carry it around the house at the rate of 300 ft. per minute, and in order to make it unnecessary to employ an operator continuously, a cage is provided, extending to within 3 ft. of the ground, so anybody can step into it from the floor and operate the machine. Some engine houses have lately been constructed with a traveling crane with a capacity of 10 tons running around the outer circle of the house, and requiring an operator continuously, but as the maximum weight to be handled does not exceed two tons, the arrangement used in the Decatur house will do the work satisfactorily and at much less first cost, and with practically no operating expense.

The water from the roof is carried off by downspouts and drained from the back of the house into the pits and into the duct from the front of the house. This duct empties into a catch-basin built on the outside of the house, which in turn is connected to the Decatur city sewer system by an 18-in. tile drain. The drop pits are drained by a 12-in. sewer pipe line connected with the 18-in. pipe line mentioned above.

The heating of the building is accomplished by a system of direct steam radiation, the steam being supplied from the boilers in the old boiler house. A 7-in. diameter main supply pipe with a pressure-reducing valve is connected to the boilers and runs underground to the duct inside the house, where it connects with a 5-in diameter main branching both ways, and reducing to a 4-in. diameter pipe. This main connects with a system of four 1½-in. pipe lines, which encircles the pits for radiating coils. These coils connect to a return system consisting of a 2½-in. and increasing to a 3-in. diameter pipe, drained by gravity to a 6 by 4 by 6 in. Worthington pump and receiver, which returns the condensation from the coils to the boilers. At two intermediate places in the duct recesses are formed to allow for bends in the main and return pipes for expansion purposes. Globe valves are provided so that any pit can be cut out of service. The pipe used in the construction of the heating system was of wrought iron. This part of the work was installed by the Peters-Eichler Heating Co., of St. Louis, in a very satisfactory manner. As it is almost impossible to heat an engine house entirely, on account of the fact that the doors are very often open a considerable length of time, only sufficient heat is provided to properly thaw out engines as they come in from a trip during the winter. For this reason only 10,000 sq. ft. of radiation was provided. So far, this has been ample for all needs, and has kept the whole house reasonably warm.

One of the essential features of a roundhouse is the washout system, which should include a scheme for changing the water in the boilers of the engines when necessary. An elaborate plan for this purpose was decided upon, with the expectation that, with such a system in operation, the boiler repairs would be considerably reduced. From results obtained so far a great saving is being accomplished, due to the large reduction in boiler repairs and to the diminished time required for washing out engines, thus greatly increasing their earning power; so the expense in installing this plant has been justified. The pipe lines in the house for this system are attached to the columns close to the roof near the middle of the house. They consist of four different lines: one for washing out the boilers, which extend over 15 stalls; one for refilling the boilers, extending entirely around the house; and two lines for blow-off purposes, one for connecting to the water leg of the engines entering 15 stalls and the other to connect to steam dome of the engines, extending completely around the house. The line that connects with the steam dome of the engines leads to a [illegible], while the blow-off line from the water leg is connected with two tanks placed one above the other, the steam entering the upper tank, and the water and impurities taking by gravity to the lower tank. In the lower tank is placed a filter which filters out the impurities in order to utilize the purified water for refilling purposes. Pumps operated by electricity are connected with the refilling and washout lines. Cold water is admitted to the system of tanks when required from the Decatur city water supply. In connection with this system there is a temperature controlling device which is intended to mix the cold and hot waters to any desired temperature before they are circulated through the house. The heater and the different tanks, with the pumps and temperature controller, are situated in a part of the building which is utilized for the machine shop. With this system an engine can enter the house and have water in its boilers removed and fresh water at practically the same temperature returned to it and be under steam and ready for the road within two hours' time.

If it is necessary to clean out a boiler the engine is brought in on one of the 15 stalls reserved for this purpose, the steam and water drawn off and the boiler thoroughly washed with water at a high temperature. The temperature of the water used is usually above that of the boiler itself so that the tubes and plates will not be cooled too quickly. There are on an average 15 engines per day blown off and refilled or washed out by this plant. The washout system was installed by the motive power department of the Wabash R. R., the preliminary plans being furnished by Mr. Frederic A. Gale. Patent rights of this system are controlled by the National Boiler Washing Co. The plant as finally constructed was not built in accordance with the original plans, but was somewhat modified.

The turntable foundations are supported by piling and are of concrete. The center or pivot foundation is reinforced with rods just above the head of the piles. The circle rail is spiked to short ties laid without any fastening on the circle wall. The pit is paved with concrete in a manner similar to that in the house and is drained by a 4-in. tile into the main house sewer previously mentioned.

The turntable is of the deck type, 75 ft. long, with a live load capacity of [illegible] tons, and is turned by means of a tractor wheel running on the circle rail and operated by electricity. The steel work of the turntable was built by the American Bridge Co. and installed by employees of the Wabash R. R. Co.

As the cost of labor for handling cinders and [illegible] from engines [illegible] increasing, amounting [illegible] per month, it was decided to build [illegible] handling system [illegible] that would reduce this cost to a minimum. The structure was planned to have sufficient capacity to hold at least all the ashes deposited by the engines during 24 hours and was provided with machinery with which to load the ashes into cars. Concrete cinder pits were constructed in duplicate, 100 ft. in length, in order to permit three engines to be on each pit at a time. The cinders from the engines fall by gravity down an incline into a concrete pit filled with water. Cinder pits are usually hard to maintain on account of the hot cinders collecting in spots and destroying anything in close proximity to them. For this reason the dumping sides of the pits on which the cinders drop are paved with brick. [illegible] supporting the track beams and rails are of [illegible] of 1 in. metal filled with concrete.

In order to handle the cinders cheaply and quickly a gantry crane is provided to

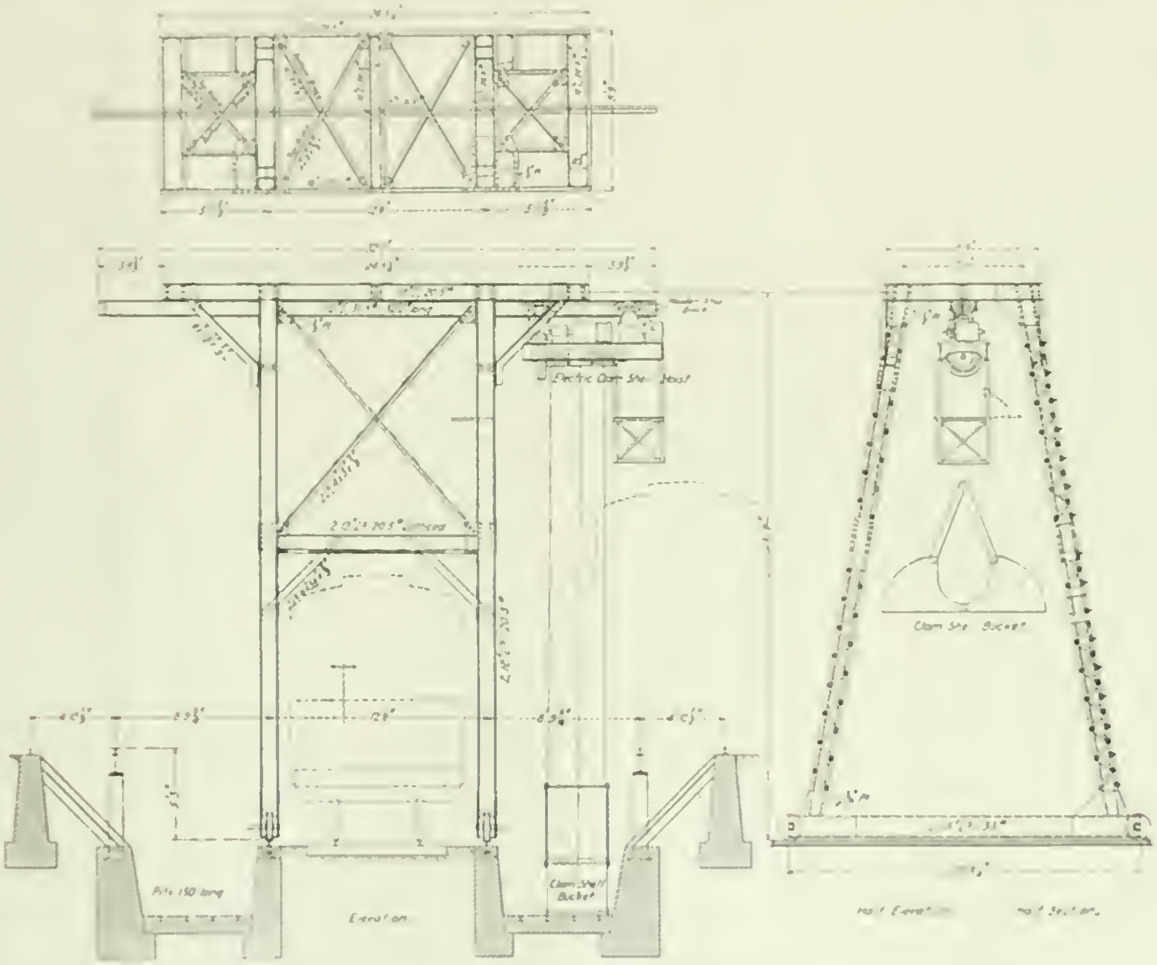


Fig. 6—Electric Gantry Crane for Handling Cinders.

run on rails between the duplicate pits, on which is hung a telpher hoist, capable of raising a 4-ton weight. This raises and lowers and operates a clam-shell bucket for picking up the cinders and depositing them in cars. A cage for the operator is attached to the telpher, so that he is directly over the bucket at all times. This gantry crane is operated by electricity and moves lengthwise of the pit, while the telpher hoist moves crosswise of the pit. This scheme has worked admirably, and while, as stated above, it cost $600 per month formerly for labor to load the cinders, with this device it practically costs nothing, for the reason that this work is done by any hostler who may be idle at the time. A certain number of hostlers have to be employed to take care of the engines during rush hours, so that any spare time they have is utilized in operating this machine. There are 70 yds. of cinders removed daily from the cinder pits.

Jas. Stewart & Co., of St. Louis, were the contractors for the house and cinder pits. The steel work for the gantry crane was constructed by the Decatur Bridge & Iron Co. The telpher hoist and machinery for the gantry crane, and the telpher hoist for the roundhouse, were constructed by the Case Manufacturing Co., of Columbus, Ohio.

The cost of the above improvements is given below in detail; but, as will be noticed, it does not include the value of the old buildings utilized nor the value of the old machinery and cost of labor for installing it in the machine shop.

Engine house and turntable foundations	$60,000	
Roofing	2,000	
Heating system with pump well, etc.	6,220	
Smoke jacks	2,100	
Door anchors	100	
Drainage and sewerage	1,950	
Wiring and lights	1,000	
Grading	600	
Engineering in field	1,000	
Track inside of engine house (value)	1,675	
Telpher hoist	1,000	
Washout system and motors	6,900	
		$ 84,545
Track between turntable and engine house and labor laying (value)		$ 1,955
Turntable pit and foundation	$ 3,360	
Turntable	2,430	
Circle rail and track on turntable (value)	685	
Machinery for operating turntable	1,075	
		7,550
Cinder pit	$ 6,875	
Gantry crane	835	
Machinery for gantry crane	2,950	
Clam-shell bucket (value)	600	
		11,260
Coaling station		8,775
Sand house and machinery (value)		2,000
50,000-gal. water tank and fixtures (value)		1,100
Three water cranes with water pipes and fixtures, etc. (value)		1,000
		$118,185

Note.—Items with the word "value" written after them indicate that the material or structure had been formerly used with the old facilities. The amount given is the cost if new.

LETTERS TO THE EDITORS.

The Form of Reinforcements Used in the Baxter Building.

Sirs: Referring to your issue of April 7, which contains the interesting contribution entitled, "Method of Constructing an 8-story Building with Some Data on Costs," it seems fitting to the writer that a few words should be added to make the article more complete.

In reading the article over the writer could not fail to notice first, that no mention was made of the name of the system of concrete construction used in the building and second that the paragraph devoted to its description failed to convey an adequate idea of the essential points peculiar to this system. Most engineers and contractors are familiar with the "Mushroom System," invented by C. A. P. Turner of Minneapolis, Minn., and of which system the Baxter Building of Portland, Me., is a typical example, and since it is known the country over by that name it should be designated as such for the benefit of the reader.

In describing the columns the statement that "the arrangement of steel acts like a spread footing built upside down" does not describe the arrangement in the Mushroom System. Correction should be made of the statement that "bars run three ways." These bars are the floor slab rods which are generally ⅜-in. rounds and they always run four ways over a column top in all standard constructions of this type. Multiple-way reinforcement is a special feature of the Mushroom System and it may be further noted that these groups of rods are made two car-lengths or 68 ft. long wherever possible. This allows the floor reinforcement to pass over several panels thus effecting considerable saving in steel by doing away with lap over each panel.

Regarding the reinforcement of the columns the tendency for the column to swell under compression is taken up in the usual way by means of hoops for heavy loading and round spiral rods in the case of light loading. The tendency for the column to bend or buckle is taken care of by the vertical rods. These rods surround the "core" or what is considered the effective area under stress of the column. In the Mushroom System these vertical rods extend up to within 2 ins. of the top of the rough floor slab and here they are bent over radially from the column until their ends reach the bottom of the floor slab. In ordinary construction two different sized round bar hoops, the smaller of which is generally 0.6 the diameter of the larger which latter may be from 6 to 13 ft. in diameter according to the distance between columns, are placed on the bent over column rods forming what is known as the "Mushroom column top." Over this top are laid the groups of parallel rods, each group of rods running in a different direction, constituting an arrangement known as multiple way reinforcement. There is more than an ample quantity of metal over the column. It will be noticed that the column top coming up as it does close to the floor level takes the stress due to the negative bending moment and at the same time serves the purpose of taking care of the maximum shearing stress near the column.

It may be stated that the mushroom system is of interest to contractors in particular in that it lends itself to rapid and economical construction, since the amount of form work is reduced to a minimum by the absence of beams. The safety and stability of the system is born out by the results of an elaborate series of tests made on the various buildings erected within the past three years and on which a failure has never been recorded.

Yours Truly,
K. P. Swensen.

816 Phoenix Building, Minneapolis, Minn.,
April 12, 1909.

Catalogs Worth Having.

Engineers and contractors should have on file the latest catalogs of machines, tools and supplies that they use. In sending for catalogs reviewed or advertised in this paper, you will confer a favor on us if you will write direct to the advertisers and state that you saw the catalog mentioned in Engineering-Contracting. If you are in the market for tools, machinery or supplies, tell us and we will notify promptly the leading manufacturers.

No. 1191. **American Mixer.**—The International Fence & Fireproofing Co., Columbus, Ohio.

This is a very good descriptive catalog. The American mixer which is described and illustrated is a batch mixer in which the drum is stationary and the mixing is done by a set of plows on a revolving shaft. Special claims are made for this feature and for the efficiency of the machine with dry mixtures.

No. 1192. **Concrete Machinery.**—The McKelvey Machinery Co., Cleveland, O.

This 40-page pamphlet illustrates and describes briefly the batch, continuous and hand power mixers made by this company and also lists the firm's line of concrete buckets, skips and cars. The McKelvey batch mixer is most particularly described, special attention being given to the patent gravity shovel which does the mixing.

No. 1193. **Steel Cars.**—The Ohio Ceramic Engineering Co., Cleveland, O.

A well printed pamphlet of 71 pages illustrating the line of cars made by this firm. Flat, dump and deck cars are most particularly described. These cars have roller bearings for the wheels.

No. 1194. **Universal Drafting Machine.**—Universal Drafting Machine Co., Cleveland, Ohio.

Describes and illustrates the Universal drafting machine. This machine consists of a graduated square having an accurate parallel motion about the drawing-board The square is adopted because the work in most drawings consists of sets of lines at right angles. Both blades of the square are graduated for drawing and measuring lines at the same time. The blades of the square chuck into place: interchangeable. Any length and any scale supplied. A straight edge is provided for inking. It may also be used for long lines. This, however, is not necessary, as lines may be quickly and accurately extended with the square. The parallel motion is obtained by means of two pivoted parallelograms, which constitute an arm joining the square to the board. This arm is made flexible, allowing the blades to lie flat upon the drawing. It is hinged at the connection to the board, and may be easily lifted out of the way of the paper. It may be readily changed from one board to another. The square is moved about the board as easily as though it were not joined to the arm.

No. 1195. **Sidewalk Lights.**—The Berger Manufacturing Co., Canton, O.

An excellent descriptive catalog of sidewalk and vault lights and lighting. These lights may be used in roofs, courts, or sidewalks, and the space under them for such purposes as salesrooms, accounting rooms, vaults, barber-shops, restaurants, etc., etc.; in fact, for practically any purpose imaginable. Uses somewhat out of the ordinary, but showing particular adaptability, are exampled by cuts of blacksmith shop, feed storage, and railroad tunnels.

No. 1196. **Copper Clad Steel Wire.**—Duplex Metals Co., New York, N. Y.

A neat 28-page catalog telling about the Monnot copper-clad steel wire made by the above named company. The pamphlet contains a number of very useful tables.

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LETTERS TO THE EDITORS [illegible]

Is It True That "Any Considerable Expenditure for the Improvement of Rural Highways Can Not Be Justified on Financial Grounds Alone?"

The quotation in the above caption is from Baker's "Roads and Pavements" (p [illegible]) and, as it has been one of the main causes of retarding road development in certain sections of the country, it is well worthy of serious consideration.

"Good roads," says Prof Baker, "are chiefly desirable for the same reason that a man buys a carriage or builds a fine house, i e, because they are a comfort and a pleasure." Is this the reason why one never sees an earth road in France or England? Is it a fact that the people of Europe have such abundant financial means that they have built good roads merely for the pleasure thus afforded? We are confident that this is not so, and our confidence is not based solely upon "horse sense," but upon a logical demonstration that few farming communities are so poor that some sort of a good road will not prove to be a wise investment.

Elsewhere in this issue appears the fourth chapter of a serial article on the theory of economic road design and location. In the fifth chapter of that article (which will appear next week) certain rules have been deduced for determining the justifiable expenditure for converting an earth road into a paved road under any given conditions. In spite of the fact that thousands upon thousands of pages of reading matter have been printed on the subject of the economic advantages of good roads, this is the first time, so far as we know, that a definite rule has been laid down for determining exactly how much money can be profitably spent in any given case to provide a paved highway. We use the word pavement in the broad sense given in Webster's dictionary, which does not exclude macadam nor even a rolled gravel road.

Prof. Baker's fallacious conclusion that a good road is never "justified on financial grounds alone" is based upon a fallacious assumption, namely that the team time spent in hauling is time that could be spent in doing nothing else, and that there is more than abundant team time available for hauling in the "idle season" after the crops have been harvested. In chapter III of our serial article we have shown the false nature of Prof. Baker's assumption, and we shall not repeat the demonstration here.

Another feature of that serial article to which attention should be drawn is that Chapter IV contains the first published demonstration of the cost of road maintenance expressed in cents per ton-mile. Maintenance costs have always been recorded either in terms of the mile of road or of the square yard of pavement per annum, and in that form they are practically [illegible] highway [illegible]. It is strange that [illegible] on railway [illegible] authors of books on roads and streets have failed to grasp the [illegible] of the advantage of using the ton-mile as the unit for expressing not only hauling costs but maintenance costs. Yet we do not [illegible] to see that no rational system of highway design is possible until the ton-mile, or its equivalent, is adopted as the unit to which all costs must be reduced.

A good road differs not a whit from a railway in the general character of the economic problems that it presents, for both are means for reducing the cost of transportation. But while the general character of the economic problems is identical, the data to be used are very different. It is greatly to the discredit of highway engineers that data regarding maintenance costs are so meagre, for this meagreness, coupled with the fact that maintenance costs have never been reduced to the ton-mile as the unit, has served seriously to mislead many capable engineers, among whom may be numbered the author of the book a quotation from which is under discussion.

"Engineering News" has sided with Prof Baker, and in its issue of Nov 17, 1908 has expressed its belief thus: "The great bulk of our highways must remain dirt roads, for one or two generations at least, if not indefinitely."

If it were true, as Prof. Baker affirms, that farm team time spent in hauling has only a nominal value (p 16 of Baker's "Roads and Pavements"), then Prof Baker and "Engineering News" would be undoubtedly correct in their prognostication that we shall always have the "dirt road" with us, and little else but the "dirt road." However, such an assumption is probably the most flagrant example of false reasoning that has ever found its way into engineering literature. That it has done incalculable harm, particularly in retarding the good road movement in such states as Illinois, can hardly be denied.

What the Great English Engineer, Telford, Said About Day Labor as Compared with Contract Work.

One of the greatest civil engineers of all time, and the greatest of his own time, was Thomas Telford, the inventor of the telford road, engineer of hundreds of large bridges and builder of numerous canals and docks. He was the first president (1820) of the Institution of Civil Engineers.

Of all the monuments to Telford's hard common sense and engineering skill none is greater than the "Rules for Repairing Roads," of which he is author. There are seven of these rules, and the most important of all was reserved for the last. Rule 7 is entitled "Management of Labor," and reads as follows:

"All labor by day wages ought as far as possible to be dispensed with. The surveyors

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> should make out specifications of the work of every kind that is to be performed in a given time. This should be let to contractors, and the surveyors should take care to see it completed according to the specifications before it is paid for. **Attention to this rule is most essential, as in many cases not less than two-thirds of the money usually expended by day labor is wasted."**

This rule was written a century ago, but time has not altered the nature of men nor the soundness of Telford's advice. Yet it was only a little more than a decade ago that the first American state passed a law giving "state aid" in road construction and prescribing that the work be done by contract. Prior to that, either the day labor system or the system of working out taxes on the roads had been the customary practice, with results that still remain a disgrace to the intelligence of Americans. Now, under the contract system of building state roads, a veritable revolution is taking place. The wonderful change in the public attitude toward road building has been attributed by many entirely to the plan by which the state shares a large part of the expense. Undoubtedly this is an important factor, but more important still is the adoption of Telford's method—the contract method of doing roadwork.

It is interesting in this connection to record Telford's success in the building of nearly 1,000 miles of roads in Scotland by contract. He let 120 contracts for this roadwork, which extended over a period of 18 years, and in that time there was not a single lawsuit arising from any of these contracts. The work was done with an economy unheard of before Telford's time, and it was small wonder that his fame spread beyond the British Isles, and led to his being called as consulting engineer on numerous engineering projects in Europe.

Telford had discovered—or rather rediscovered—the principle that workmen are far more efficient when in the employ of an individual or firm than when in the employ of a government, whether it be a county, town, city or state. His success as an engineer rested as much upon the application of this principle as upon his own genius as a designer of engineering structures.

Within the last few years, concomitant with the revolution in the political economy of road building, there has come a reaction against the contract system. It is seen in several cities where municipal asphalt plants have been established, and in other cities where labor unions are demanding the abolition of the contract system. But the most conspicuous example is the Panama canal. Fortunately, if the full facts become generally known as to the enormously high unit costs at Panama, this blunder in administration will stand as a gigantic monument to warn others away. Nevertheless, at present the Panama example is having its pernicious effect.

Engineers who have executive capacity are urging municipal authorities to build municipal plants for doing this, that and the other thing by day labor. Only a few weeks ago it was proposed in Detroit that the city build a plant to make its own paving bricks—and why not? If there is logic in building and operating such a municipal asphalt plant as Detroit has, why stop there? It is equally logical to go into the manufacturing business and produce paving blocks, or sewer pipe, or, indeed, any product, tool or machine that the city needs.

Every manufacturer is a contractor—nothing more, nothing less. The primary difference is that the manufacturer has a fixed plant, whereas the contractor moves his plant from place to place. The contractor who builds a concrete sewer is as much of a manufacturer as the firm that makes vitrified sewer pipe. Who is there demanding the abolition of the private manufacturing system of production? Not many as yet, although the demand has been voiced at Detroit as far as bricks are concerned. Yes, and the U. S. Reclamation Service built a cement factory, and one was seriously considered by the Panama Canal Commission.

ENGINEERING-CONTRACTING is making no idle plea for the continuance of the contract system when such papers as "Engineering News" advocate the building of the Panama canal and the dredging of New York harbor by day labor. Has the News forgotten Telford's seventh rule for economic road construction? Or was that rule unknown to the News? We commend a study of it and consideration, because of the fundamental principle involved.

Engineers frequently ask why ENGINEERING-CONTRACTING opposes the day labor system. One of our readers not long ago wanted to know whether we regarded engineers as being inferior to contractors in executive ability. Candidly, we do, taking engineers as a class, for not many of them have had the necessary training as managers. But, on the other hand, many of the most successful contractors are engineers, and their engineering training has been of great aid in their advancement. The question, however, is not whether engineers possess executive ability, but whether any man can so change the nature of workmen as to secure their best efforts when working for an employer whom they never see. Such is the fact. The employer of the workmen at Panama is not Col. Goethals, for he is but an employe himself. He has not even seen the great composite picture of the ninety millions who employ him. The employer is wealthy beyond the dreams of avarice—this ninety million composite man. What if it does cost him a little more? It won't break him. What if I do loaf a bit? Who will tell him? Why should I scheme to devise a labor saving method or appliance? He will never reward me. He doesn't even know me, and never can.

Whether such thoughts as these, or others, actuate the man working by the day for the government, the fact remains that the surest way to make a workman slothful is to pay him directly out of the purse of Uncle Sam. Nor is the city, county or state purse any less sporific in its influence.

A contractor's profits do not represent a sum taken by a useless "middleman," as so many engineers seem to think. Such profits are the payment for skilled supervision and for courageous experimenting with new machinery. They represent in part the margin of difference between mediocrity and excellence.

Profits are prizes in the industrial game, which convert labor into play and change the whole attitude of a man toward work. To the man who plays the game most skillfully comes the largest prize, yet, in the end, the public is also a sharer, for competition inevitably prevents the contractor or manufacturer from taking more than a moderate fraction of the saving that he effects.

If you wish to make drudgery of work, pay managers on a salary basis and hire men by the day. If you aim to make work a pleasure, pay all men in proportion to their performance under competition, giving profits to the contractor, or manufacturer, and wages plus a bonus to the workmen.

To the lasting credit of Telford it will be ever said that he was the first great engineer to perceive the economic importance of this principle; and it was largely due to his keen perception and application of the principle that he owes his greatness.

A ship canal across Scotland is now being discussed. At the present time there are two waterways across Scotland. One of them is the Caledonian canal, which has a large number of locks and will receive vessels up to 160 ft. in length. The other is the Forth and Clyde canal, 39 miles long, 27 ft. wide at the bottom and 10 ft. deep, which was opened for traffic in 1790. None of the projects under discussion relates to the Caledonian canal, but there are several with regard to the other. One of them is to enlarge it to accommodate the heaviest battleship of the navy, and the other is to alter it into a tidal canal with hydraulic lifts at each end. Other plans for a ship canal have also been proposed. One of these starts in the neighborhood of Clydebank and runs along the Forth and Clyde canal for some distance and then through the valleys of the Kelvin, Bonny and Carron to the Forth river. This project contemplates six locks at each end of the canal. Another route is from Grangemouth on the Forth to Loch Lomond, up that lake and across a narrow neck of land to Loch Long, and through the latter to the Firth of Clyde. This last route is advocated by the Forth and Clyde Canal National Association, and is estimated to cost about $90,000,000. Although it is believed that a canal along any of these routes would be used to a considerable extent by merchant vessels, the main argument for the great expenditure is military, and a decision to build along any one of the routes is likely to be determined by the strategic importance of the work.

Harbor improvements to cost $9,000,000 on the part of San Francisco are authorized by a bill just passed by the California legislature. The scheme must have the sanction of the voters of the city.

Concrete and Reinforced Concrete Section

Note:—This section is devoted to methods and cost of constructing concrete and reinforced concrete structures. It will cover the selection, testing and proportioning of concrete materials; laboratory tests of concrete; concrete mixing, transportation and placing; fabrication and placing of reinforcement, and form construction and erection. It will also contain articles on new and interesting developments in the design of reinforced concrete.

Method of Constructing Interlocking Concrete Pile Sea Walls and Foundations.

There has recently been [illegible] in Chicago a method of sea wall and foundation construction of interlocking concrete piles which has several points of interest and novelty. While the same method has been previously employed in Colorado in a few structures, this Chicago work is its first use with plans established and all details worked out. The work in question consisted in inclosing an area of reclaimed beach on the shore of Lake Michigan and raising it by filling and of constructing foundations for a large residence on the reclaimed area. Briefly, the work consisted in sinking a row of interlocking concrete piles practically inclosing the reclaimed area and of sinking similar piles in rows or clusters to support the residence foundations.

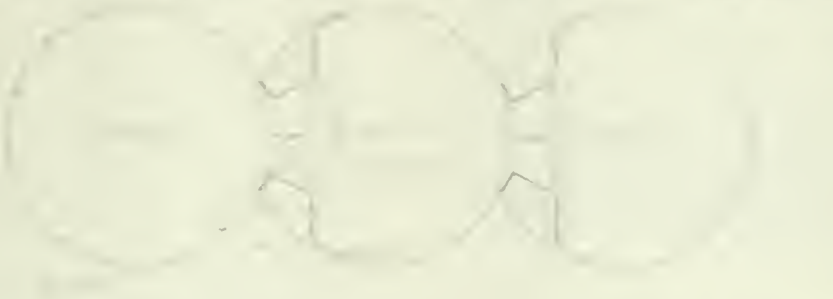

Fig. 1—Sections of Interlocking Steel Shells.

The construction consists in sinking by jetting sheet steel shells, filling them with concrete as they sink. Figure 1 shows the shell construction for round piles, and the interlocking detail will be noted. Other shaped shells may be used, a standard shape being two flat ends connected by flat arcs forming sides—an oval with the ends cut off and closed by flat plates on which are the tongues and grooves. In the Chicago work mentioned, round shells [illegible] ins. in diameter and 16 ft long were used. In construction the shell is fabricated to full length with closed bottom. It is up-ended and enough concrete put in to settle it to the bottom in water. Staging is built from which to work the jets and handle the concrete and these stagings serve also to guide the shell in sinking. When the bottom is reached the water jets are shoved down alongside the shell and loosen and remove the soil into which the shell slides. The method of sinking is exactly similar to that used in jetting timber piles. As the shell sinks it is filled with concrete. The second and each succeeding shell is sunk by inserting its tongue in the groove of the preceding pile and setting it down alongside it and interlocked, [illegible] the pile in place.

It is plain from the preceding description that the line of piles may turn corners at angles by simply locating the tongues and grooves in the proper position on the shells. Moreover it is [illegible] that the [illegible] can be reinforced in any way desired by simply inserting the proper metal in the shell before filling in the concrete. If buttresses are desired two or more piles [illegible] at right angles to the main line of wall. In fact an almost endless variety of arrangements is possible, since the tongues and grooves can be located at any point on the perimeter of the shells. A variation [illegible] of the shells is in arch bridge construction. In such cases the shells are curved to the arc of the arch and interlocked side by side the ends resting against the abutments. Holes in the top surface of the shells permit filling with concrete. Bridges of this form have been constructed in Colorado, and, it is stated, at a decided reduction in cost compared with ordinary types of concrete arches.

The particular field of this form of construction is, however, cofferdam work, walls for docks, jetties, wing dams, retaining walls, foundations and the like. This is well shown in the views Figs. 2, 3 and 4 of the Chicago work mentioned above. Figure 2 shows the method of sinking the shells and Fig. 3 shows the completed wall being filled in by hydraulic dredge. Figure 4 shows a row of shells forming the [illegible] testing for use of the walls at any point desired.

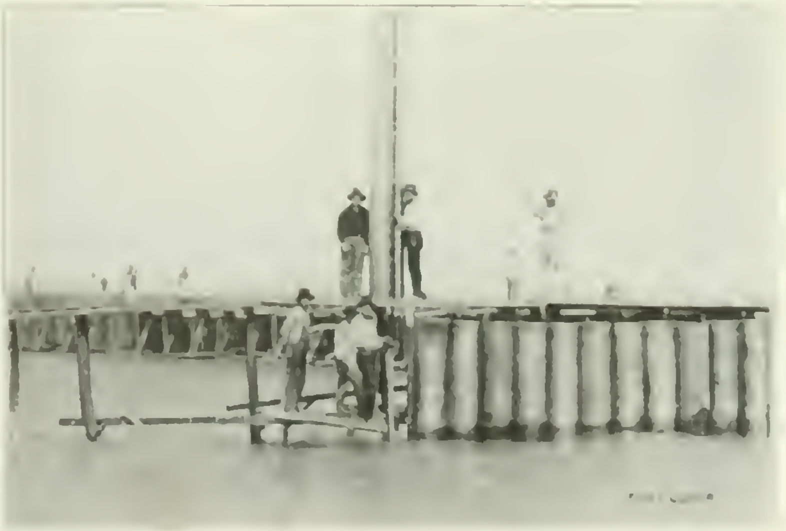

Fig. 2—Sinking Interlocking Shells by Jetting.

The company controlling the rights of construction is the [illegible] Construction Co., Chicago, Ill.

Method and Cost of Constructing a Reinforced Concrete Trestle.*

The trestle replaced an old wooden trestle 250 ft long on a cable incline railway up Catskill Mountain, New York. The general structural features of the trestle and the slope of the ground on which it was built are indicated by the accompanying sketches. The work was done by contract after the cable railway had closed down on Oct. [illegible], 19[illegible], for the season. Parts of the old timber structure were then available for supporting forms and for such other purposes as the contractor required this kind of timber.

While waiting for the materials to arrive and the road to close down, excavation was begun on the footings, stone for the concrete was broken, a pipe line [illegible] ft long was laid to a waterfall, a cement house and a shanty in which to fabricate the steel were built.

In excavating for the footings it developed that there were alternate strata of slate rock and earth, with boulders in about half of them, so that to get a good foundation on bedrock it was necessary to go from 4 to 10 ft below the ground, the surface of which was so steep that it was very difficult to work on it. Slides and caving caused a much larger quantity of material to be handled than that represented by the holes excavated.

The excavations were walled up in pyramidal form on a batter of 2 ins. to the foot outward to within 2 ft of the ground surface, there narrowing to a section [illegible] ins., on top of which a wooden box 30 ins. square and 24 ins. high was set up. Every bent had two such forms for the batter post footings and every alternate that had in addition a third for the [illegible] and bracing strut to meet on. Then footings were concreted with a mixture of 1:3:6, the stone being broken by hand to 1½-in. size and the wooden box forms being butted ahead as the work progressed, the [illegible], mixing board, etc., being likewise shifted ahead. [illegible] of the lumber was stored at the lower end of the trestle and half at the middle; half of the sand at the middle and half at the upper end; half of the steel at the lower end and half at upper end, and all cement at the middle.

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*Condensed and rearranged from a paper by [illegible] in Engineering Record, [illegible], 1909.

Five mixing boards were established along the trestle, and stone was broken successively at each as it was needed for the concrete. The water pipe, which ran alongside, was shortened as the work progressed. The sand and gravel were separated by screening and sent to the mixing boards through temporary chutes, the superstructure concrete being 1 part cement, 2 parts sand, 2 parts ¾-in. gravel and 2 parts ¾-in. stone.

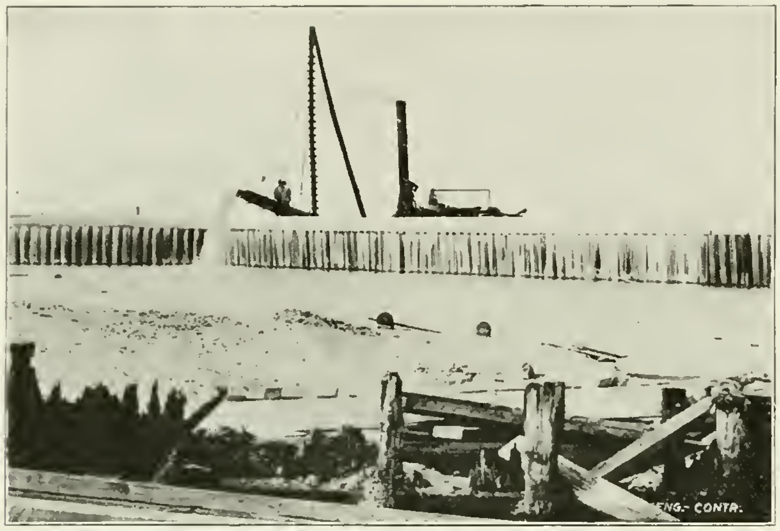


Fig. 3—Filling Behind Completed Sea Wall of Interlocking Shells.

Work was begun with a force of 10 men working 9 hours, of whom 1 was a foreman drawing $4 a day, 1 carpenter at $2.50, 1 steel bender at $2.25, and 7 laborers at $1.75 each. When the road closed down the force was doubled, 8 more laborers being added at $1.75 and 2 carpenters at $2 and $3.25, respectively, these latter working for a bonus.

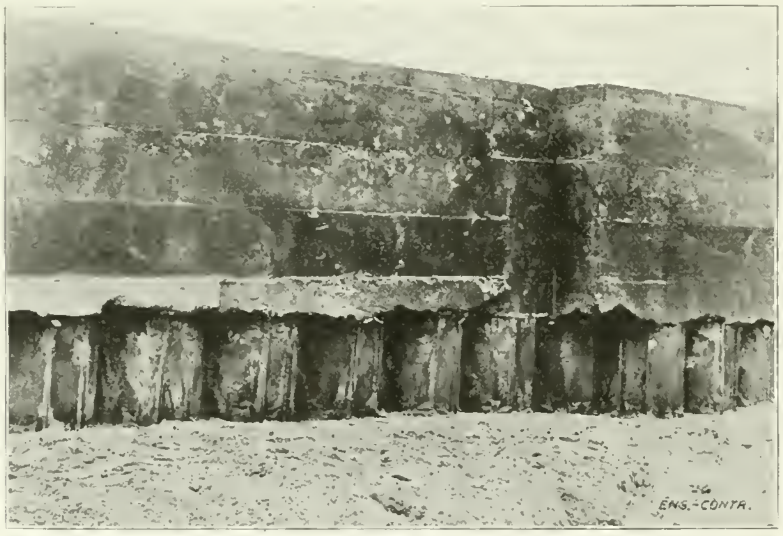


Fig. 4—Foundation Footing on Interlocking Shells.

Concreting the footings began on Oct. 18 and dismantling the old trestle at the same time, with some men fabricating steel, some building forms, some breaking stone and some excavating the upper footings.

The pulleys were first removed from under the cable, and the latter supported by 2x4-in. plank spiked to the old trestle bents, on which were also preserved the line and grade. The guard rails and track rails were next removed, then the cross ties and four inner stringers were unbolted and lowered by ropes to the ground and piled so as to form mixing boards. The remaining outside stringers were then shifted out to the ends of the bent caps, leaving a clear space in the center 8 ft. 6 ins. by 26 ins. deep. In some places the tops of these stringers were 2 ins. above grade and in other places 2 ins. below, otherwise they represented approximately the level for the new work and allowed a clearance of 3 ins. for the outside girder form of the new work. Next 2x6-in. spruce floor timbers for the girder forms were hung at 3-ft. intervals on a grade 27¼ ins. below by 2x4-in. battens spiked to the outside of the old stringers. The old bent caps were then gained out for each new girder to the grade of the floor timber, and a 1¼x12-in. by 16-ft. bottom board for each of the three new girder forms nailed in place. These girder forms were then built up to a depth of 26 ins. of 1¼x9-in. spruce matched boards, 1¼x4-in. pieces being used for battens every 36 ins. These sides were braced internally at 3-ft. intervals by tablets taken from the footing forms and placed like cross-partitions between the girder forms. The outer sides were braced by wedging against the 2x4-in. hangers and old supporting stringers, the tops of the latter being held from gaping outward by 1¼x4-in. strips nailed across the top over the floor timbers. The three floor timbers at the center of each span were then further supported from below by struts composed of old ties and braces from the dismantled structure.

The forms for the batter posts and bracing struts were made up in trough form, leaving the outer and upper side open, then set in place on the foundation, and the tops sawed to fit the bottom of the girder forms. The webs were then built between their tops, uniting the whole with the girders. The post and strut forms were then properly braced and supported, the reinforcing steel put in place, a section of the fourth side put in place and the whole securely clamped together by ¾x26-in. bolts passing tangent to two sides and drawing 2x4-in. yokes against the remaining two sides.

The reinforcement having been placed in the girders, the concrete was then poured in and carefully rammed and spaded, and the third side built up and clamped directly ahead of the concreting so as to permit the most careful placing of the latter without chance of displacing the reinforcement. These posts were concreted together up to the level of the girders for two bents usually. Owing to the 30° surface, the tops of the girders had to be boarded over continuously as the concreting progressed to keep it from running out, and a section of 1-in. pipe had to be left in place every 4 ft. in the outer girders through which to bolt the track to the new structure. When concreting stopped for the day bulkheads in the form of saddles were placed in the web at a bent, these bulkheads being removed the next day, allowing the concrete of each girder on the succeeding day to begin half way in the web of the preceding bent.

Each batter post was reinforced by a rack composed of ¾-in. rods wired to dowels in the footing or let into holes drilled in bedrock, extending up through the girder above it nearly to the top surface and bound together every 18 ins. by a rectangular hoop of ¼-in. corrugated bar, previously bent to the right form and securely wired together. These racks were made up as needed, and when set in place inside the forms had about 1 in. of clearance around them and had to be constantly watched by the man ramming the concrete to keep them centered. Each strut brace had a ¾-in. rod within 1 in. of each of its two lower corners, wired to the footing dowels and passing up through the central girder nearly to the surface, and requiring great care in placing the concrete to maintain them in place.

Each girder had two ⅞-in. bars suspended from the cross-batters on top of the forms by wire, so that they lay 1½ ins. below the upper surface continuously, and two intermediate 8-ft. bars over each web for continuity. At 6-in. intervals eleven stirrups were hung on them at the bent webs and two more were hung near the center of span, so that they lay in V-shape normal to the axis of each girder and 1 in. distant from its bottom and sides. Four ⅞-in. bottom bars were then hung or laid in these stirrups, the length being 34 ft.; two were made to break joints at each bent. When these bars were all in place and securely wired, two ¾-in. bars were sprung into the cross-struts at the center of span and four more in each of the webs and wired in place. Whereupon the girders were ready for concreting.

The congestion of steel at the webs made it difficult to place the concrete and properly ram it at and near the webs, and particularly to place and remove bulkheads and clean out the forms before going ahead with the concreting. It was also hard to place the concrete in the top of the bracing struts. The best results in placing the concrete were attained with a very wet mix, poured so that the water would flow up the forms ahead and be followed by a grout, which ran all around and between the reinforcement, leaving the stone and gravel to be rammed down into it at last.

The mixing was done by hand, the gang being divided so that one batch was being separated while the other was being deposited. The sand and gravel were sent to the board by a chute, the stone broken at the edge of the board as used, and the cement carried to the board, each man taking a bag as he came to work and after lunch. Inclined runways of plank were shifted from bent to bent for the posts and others built from the mixing board to the top of structure and planks laid along the sides of the girder forms in such manner that the employes could return to the board without interfering with the loaded pails. Owing to the steepness of the ground and of the grade on the finished work, there was unusual danger of accidents and need of constant vigilance to prevent bad results from careless work, and this is the reason why only so many men were employed and in such a manner.

Because of the unexpected depth of thirteen of the footings, a ⅞-in. steel bar encased in 6 ins. of concrete was placed as a tie between the batter post feet wherever the latter did not reach directly to bedrock. This and 37 cu. yds. of extra concrete not indicated on the plans and a corresponding quantity of excavation not originally called for delayed the completion of the work, which was to have been finished on Dec. 1, so that it took until Dec. 12 to complete it. The weather was unusually favorable, being dry and warm until Nov. 3, from which time on there were light squalls of snow, succeeded by mild weather till Dec. 1, when it became so cold that the aggregates had to be heated. An old section of steel smokestack, 4 ft. in diameter and 12 ft. long, was filled with fire and sand and gravel piled over it, the water being heated in pails over a fire.

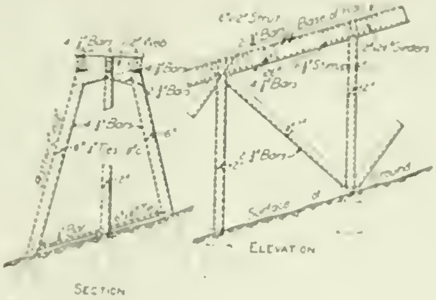
The 14 M ft. of form lumber sufficed to complete about half the forms, and thereafter the forms first concreted, having been filled ten days, were stripped and the lumber used as the form work progressed. When the clamps were removed the post forms came off in four pieces in good shape to be set up again at once, but the girder and web forms had to be taken apart and rebuilt.

The top boards and tie strips were first pried off the top of the girders, the hangers and floor timber next removed, then the old stringers pried off and lowered with ropes, all the girder batters then knocked off, and the form boards taken off separately from both the outside and inside of girders, webs and struts. The bottom boards to the girders and diagonal strut braces were left in place two weeks longer, with props under them, and then the old bent caps were sawed in two and the bent timber unbolted and dismembered, releasing the bottom boards, which were then removed, leaving the concrete completely stripped.

There was very little pointing necessary except on the posts, which was done from a ladder, after which the exterior surfaces were given a wash of cement, alum and lye, rubbed in with a cement brick to waterproof the structure and remove board marks. The cable was blocked up on the concrete webs, the ties and guard rails bolted on, the pulleys rehung and track laid back in place by the Otis Railway Company, replacing track not coming under the contract.

The amount of work done under this contract was as follows: Excavation called for 87 cu. yds. earth, and extra excavation uncalled for 63 cu. yds. boulders, making a total of 150 cu. yds.; dismantling and piling 34 M ft. yellow pine structure; 37 cu. yds. concreting (1-3-6) in extra footings; 125 cu. yds. concreting called for (1-2-4), reinforced; 13 tie rods for batter post feet; cleaning up and removal of debris; total cost $4,332.14; contract price, $4,000; extras, $677.75; total, $4,677.75; profit on contract, $345.61.

Daily records were kept, showing kind of weather, temperature, amount of each kind of work done, with proportion of pay roll spent in doing it and the unit cost noted down for the immediate purpose of more economically planning the next day's work. A distribution statement showed the cost of both labor and material, charged up against each item of work performed during the week and the unit costs computed for each. A comparison was made between weekly average and daily rates, and the conditions prevailing on those days showing the most economic rates were then planned for the succeeding week's work.



Detail of Reinforced Concrete Trestle.

Separate records were kept for the items applying to the general contract, the costs on extra work being kept apart. Finally all the costs were referred to the quantity of work done under them in the form of unit prices per cubic yard and the percentage which each represented to the whole.

The itemized cost of the work is given in tables I, II and III.

TABLE I.—COST OF 125 CU. YDS. OF REINFORCED CONCRETE

Materials	
Cement	$2 31
Sand	1 73
Stone	2 00
Gravel	0 33
Water	0 35
Total materials	$6 72
Labor	
Mixing and placing	$1 91
Pointing up concrete	0 47
Waterproofing concrete	0 60
Total labor	$[illegible]
Grand total concrete	$[illegible]
Forms	
Lumber, bolts and nails	$[illegible]
Fabricating and erecting	[illegible]
Total forms	$[illegible]
Reinforcement	
Materials, bars, wire, etc.	$[illegible]
Fabricating	0 [illegible]
Placing	[illegible]
Total reinforcement	$[illegible]
Grand total for concrete work	$[illegible]
Miscellaneous	
Excavation, 87 cu. yds	$[illegible]
Dismantling old trestle	1 [illegible]
Cleaning up at completion	0 40
General expenses, superintendence, etc	4 45
Total miscellaneous	$6 41
Grand total	$[illegible]

TABLE II.—COST OF EXTRA FOOTINGS, 37 CU. YDS., AVERAGING 1½ YARDS IN A PLACE.

	Per cu. yd.
Excavation, 63 yds. rock at $2 [illegible]	$4 91
Aggregates: Cement, $1 94, sand $0 97, stone, $1 01	3 92
Forms, material	1 20
Forms labor	1 44
Concreting labor	[illegible]
37 yds. concrete	$13 [illegible]

TABLE III.—THIRTEEN EXTRA TIE RODS ⅞-IN. STEEL IN 6X6-IN. CONCRETE, 1½ CU. YDS. CONCRETE.

	Per cu. yd.
Excavation	$[illegible]
Bending and placing steel rods	7 [illegible]
Form labor	[illegible]
Form material	[illegible]
Reinforcement (steel bars)	5 10
Concreting labor	[illegible]
Aggregates: Cement, $2 70, sand $1 3[illegible], stone, $3	7 0[illegible]
1½ yds. concrete	$47.[illegible]

Tremies are being employed in depositing concrete under water for the new Detroit River tunnel of the Michigan Central. The concrete around the tubes is deposited by means of these tremies operated from a barge, on which is the concrete mixing plant. The tremie tubes can be raised and lowered in the three towers. When the scow is anchored over one of the 23 compartments in each section of the tunnel, the middle tremie will deposit concrete between the two tubes and each side tremie between the tube and the wooden side wall. The tremie tubes are built of riveted steel. The walls are laminated spirally to eliminate as much as possible the sticking of the concrete to their sides. These tubes are a few feet longer than the deepest part of the river, so that they can reach the bottom at any point. They can be raised in the towers until the opening is very near the surface of the river. Thus the concrete can be deposited from the bottom of the tube directly into the mass of concrete in the form, no matter what its elevation may be. In starting the operation of concreting, two or three old cement bags are generally stuffed into the top of the tube. The wet concrete is now poured into the hopper and this forces the bags down the tube. The bags with the concrete on top form a water-tight plunger which forces out the water. By continually maintaining the tube full of concrete the water can be kept out, thus eliminating the greatest difficulty in the depositing of concrete under water—the sifting of the mixed concrete through water. The placing of a nearly dry batch of concrete in the tube with the wet on top has also been tried, and this is also very effective in driving the water out of the tremie at the start of the work. In order to maintain a seal at the foot of the tremie tube which will keep out the water, it is necessary to have the tube several inches under the surface of the wet concrete. To make it possible for the men on the scow to know how deep the end of the tube is sunk in the concrete, a "floater" attached to a wire which works an indicator on the scow is suspended alongside the tremie. This "floater" consists of a 12-inch ball with a specific gravity a little greater than that of water. The ball sinks to the top of the concrete, where it is held. It is said that the concrete around the end of the tube varies in depth from 6 to 12 inches. The wet concrete flows horizontally, forming a circle about 10 feet in diameter around the tube.

Earth and Rock Section

Note: This Section is devoted to methods and costs of excavating earth and rock and building embankments. It will cover the grading of roads and railroads, diking and canal work, dredging, building reservoirs and earth dams, sewer and water pipe trenching, quarrying, etc.

Suggestions in Regard to Earth Shrinkage and Overhaul, and the Use of Graders and Steam Shovels on Railroads.*

BY F. PARDOE WILSON, C. E.

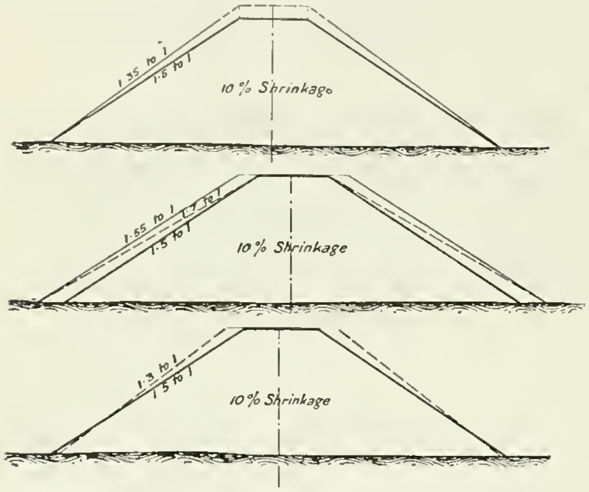
This paper is compiled from notes made by the writer whilst Resident Engineer of Construction for the Canadian Pacific Railway Grade Reduction and Revision, Medicine Hat Section, 1907-8.

It is submitted primarily with a view to elicit the practice of the profession with regard to shrinkage and overhaul, and the discussion on points raised herein, the author trusts, will be of greater value than the paper itself.

Shrinkage.—The first question that comes up in this connection is: "What is the contractor to be paid for?"

On prairie work, when light, embankment quantities are often taken, and, considering the practical impossibility of accurately measuring shallow borrow pits, as left by the generality of contractors and sub-contractors, it would seem to be the most accurate method.

If, however, work is paid for from cut quantities, to be rational, all borrow pits must be staked and measured. The practice of paying for cuts up to limit of haul and balance on embankment quantities is not logical.



Figs. 1, 2 and 3—Methods of Applying Shrinkage.

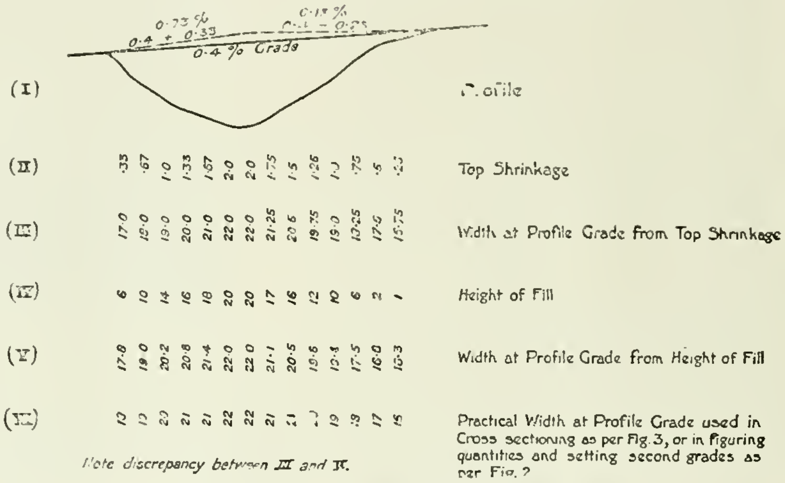


Fig. 4—Comparison of Shrinkage

In the case of excavation quantities, the question of shrinkage is not a live one with the contractor, but the reverse is the case when embankment is paid for.

A method of applying shrinkage is required to be sufficiently elastic to meet the variety of conditions met with in the field, and at the same time sufficiently exact to do justice as between the company and the contractor. This question is often a bone of contention between them on account of the magnitude of the quantities involved being overlooked.

On side-hill ground, and when cuts and fills alternate rapidly, and are of considerable extent, the theoretical shrinkage, if applied on top, would lead to anomalous conditions. When track laying has closely followed construction, cases are not unknown where the top shrinkage applied has had to be removed, or where, as illustrated in Fig. 4, the shrinkage, if not immediately taken up by settlement, might exceed the permissible grade.

From these considerations it would appear reasonable to omit raising the fill above profile grade and applying side shrinkage only to make a full shoulder so as to carry the material required to make up to grade as bank settles.

Figure 1 shows the usual method of applying shrinkage, whilst Figs. 2 and 3 show modifications of this method according as to whether or not excess quantities are permissible, or whether or not it is thought desirable to steepen the side slopes.

Setting the slope stakes 1.3, 1.4, 1.6 or 1.7 to 1 instead of the customary 1.5 to 1 is easily done in the field by adding or subtracting 1/10 or 2/10 for every foot in height of fill to the 1.5 to 1 half breadths.

Tables 1, 2 and 3 are inserted for purposes of comparison; the quantities being based on these different methods of applying shrinkage (figured to profile grade only) whilst the actual percentage increase from the standard roadbed and side slopes, is stated.

To provide the full shoulder (always desirable), the width required at profile grade from considerations of height of fill at that point (Fig. 4) is taken, reduced for

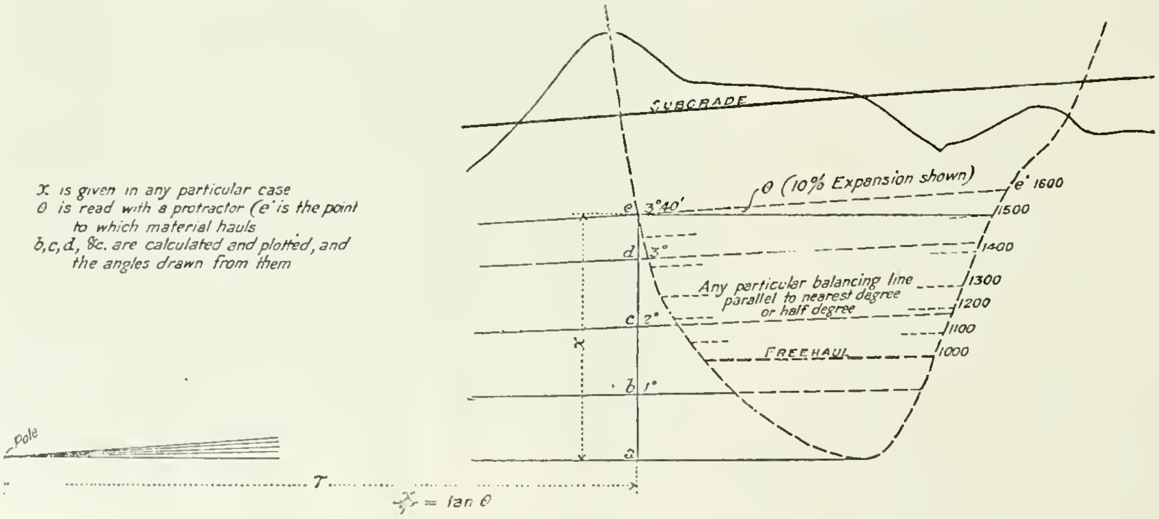

x is given in any particular case
θ is read with a protractor (e' is the point to which material hauls
b, c, d, &c. are calculated and plotted, and the angles drawn from them
SUBGRADE
θ (10% Expansion shown)
e' 1600
e 3°40'
1500
d 3°
1400
Any particular balancing line parallel to nearest degree or half degree
1300
1200
c 2°
1100
FREEHAUL
1000
b 1°
x
a
Pole
T
x/T = tan θ

Fig. 5—Diagram Showing Method of Figuring Expansion in Overhaul.

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*A paper presented before the Canadian Society of Civil Engineers.

practical purposes to the nearest foot and slopes stakes set in accordance with Fig. 2 or 3.

This representation in the cross section notes of the quantities to profile grade represents the cross sections as they are staked without additions or alterations, and avoids complication and consequent chances of error in figuring the quantities. It gives a definite and straightforward basis to work on, and enables another man to pick up one's notes and follow what has been done.

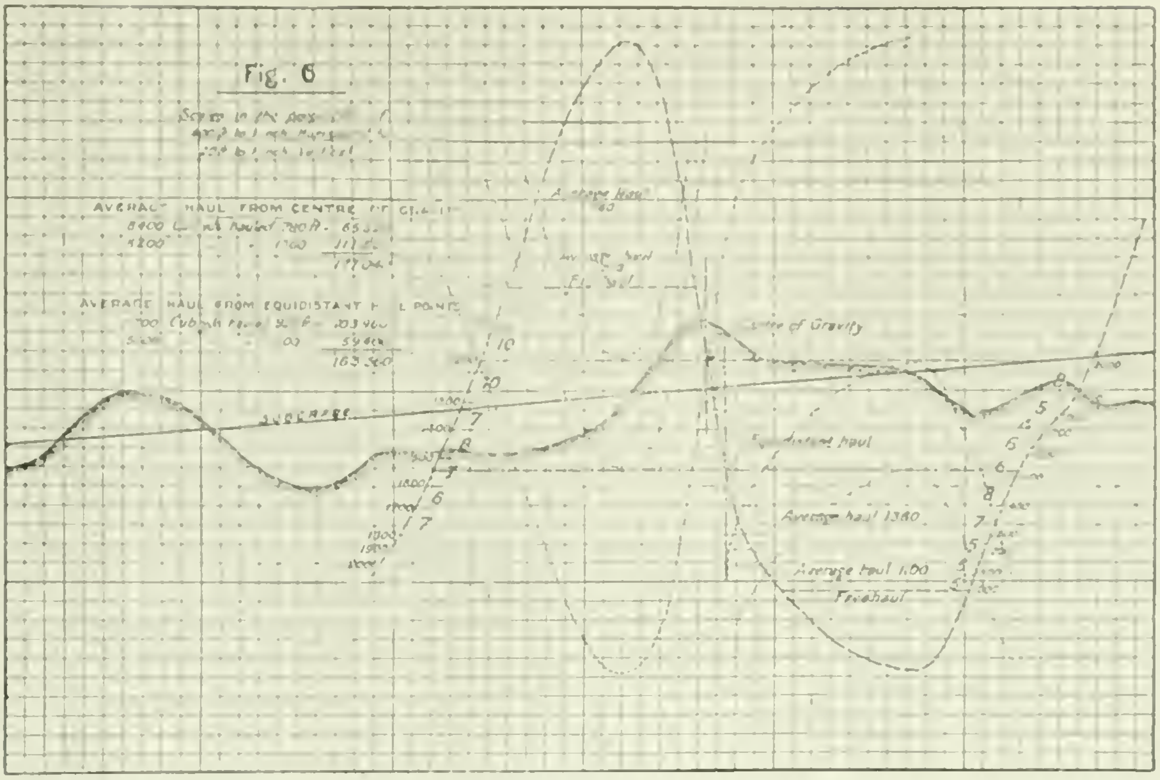


Fig. 6—Showing Overhaul Diagram on Field Profile.

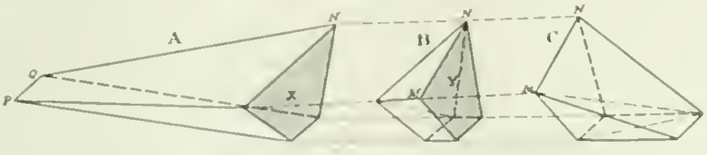


Fig. 7—Prism of Road Crossing on a Skew.

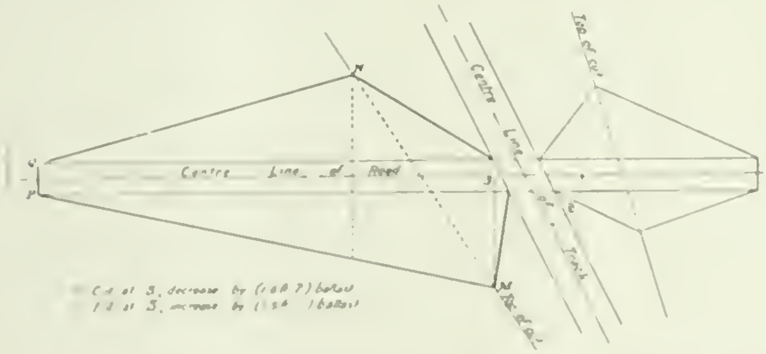


Fig. 8—Plan of Road Crossing on a Skew.

In paying for embankment quantities if an arbitrary classification of shrinkage is adopted, such as:

Team and slip work	*Nil*
Wheeler and wagon work ...	5%
Dumpcar and wheelbarrow ...	10%

and from a consideration of the fact that earth, when first moved by these several methods, expands about that same percentage, it would appear that the old expedient of putting on shrinkage and paying for neat embankment quantities is not very wide of the mark after all.

[For further information on earth shrinkage see Gillette's "Earthwork and Its Cost," Chapter I.—Editors.]

Overhaul.—Here, again, the first question that arises is: "What is the contractor to be paid for, theoretical or actual overhaul?"

If paid for actual overhaul, it often happens that through some extraneous conditions as, for instance, down-hill haul, by the method of handling the work, or perhaps on account of a structure not being built in time, the most economical distribution of the material, from the company's point of view, is not followed out.

When, however, the material expands considerably, as in a rock cut, the contractor would get the worst of the bargain unless the actual haul is used.

Another point in connection with the actual haul made by contractor is the case where borrow is made between two hauls, generally this borrow is put in by slip work all in the bottom of the fill and the actual haul made difficult of determination without elaborate figuring and close watching of the work, as the two hauls close on completion, and is often impossible under these circumstances.

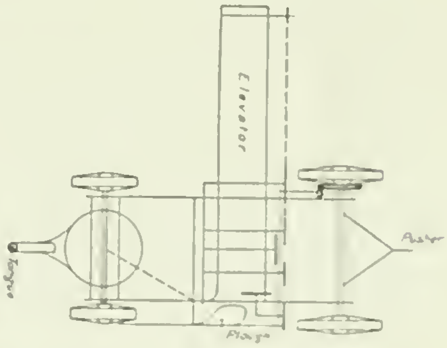


Fig. 9—Plan of Elevating Grader.

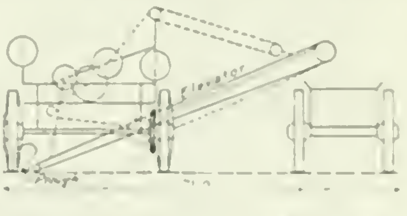


Fig. 10—Elevation of Elevating Grader.

In this case it is necessary to give the theoretical overhaul, unless, in cases of rock, when the method shown in Fig. 5 should be used, assuming some equitable percentage of expansion as found by measurements or taking actual haul.

TABLE No. 1.

Fill Ht. in ft.	Slopes.	R.B.	Cubic yds.	5% Fig. 1 Cub. yds.	Slopes.	Actual %.	10% Fig. 1 Cub. yds.	Slopes.	Actual %.
10	1.5	16	1148	28	1.425	2	55	1.35	5
20	1.5	16	3407	111	1.425	3	222	1.35	6
30	1.5	16	6778	250	1.425	4	500	1.35	7

TABLE No. 2.

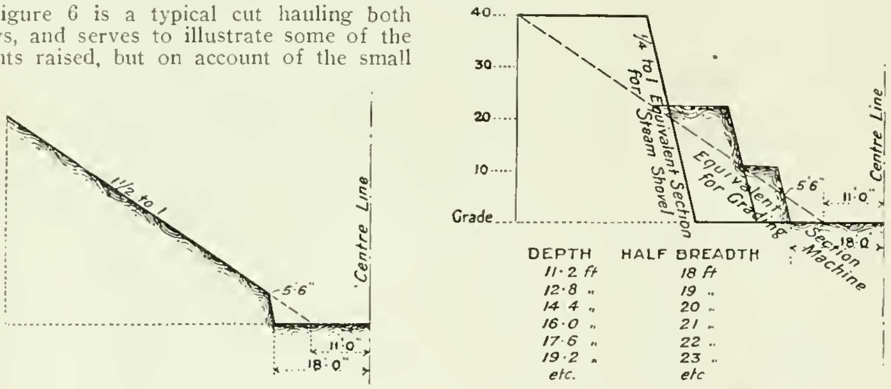
Fill Ht. in ft.	Slopes.	R.B. for setting stakes.	R.B. used in figuring X sect.	Cubic yds.	Nominal shrinkage 5% Fig. 2 Cub. yds.	Actual percentage increased quantities over a 16′ roadbed 1.5 — 1.
10	1.6—1	16	17.5	1185	30 + 37 = 67	6%
20	—	—	19	3555	118 + 148 = 266	8%
30	—	—	20.5	7111	266 + 333 = 599	9%
					10% Fig. 2.	
10	1.7—1	16	19	1222	63 + 74 = 137	12%
20	—	—	22	3703	252 + 296 = 548	16%
30	—	—	25	7441	566 + 666 = 1232	18%

TABLE No. 3.

Fill.	Slopes.	R.B. for X section and setting stakes.	Cubic yds.	Nominal shrinkage 5% Fig. 3 Cub. yds.	Actual percentage increased quantities over 16′ roadbed 1.5—1.
10	1.4	17.5	1166	18	1%
20	—	19.0	3481	74	2%
30	—	20.5	6944	166	3%
				10% Fig. 3.	
10	1.3	19	1185	37	3%
20	—	22	3555	148	4%
30	1.3	25	7111	333	5%

Figure 5 illustrates the method (which is self-explanatory) of figuring expansion in overhaul.

Figure 6 is a typical cut hauling both ways, and serves to illustrate some of the points raised, but on account of the small quantities of overhaul does not bring out very forcibly the discrepancies in the various methods of calculating.



Figs. 11 and 12—Methods of Staking Cuts for Elevating Grader Work.

From this figure it is evident that the c. g. of cut is not the most economical distribution point, but the point that such a cu. yd. can be hauled either way at the same cost is the point wanted.

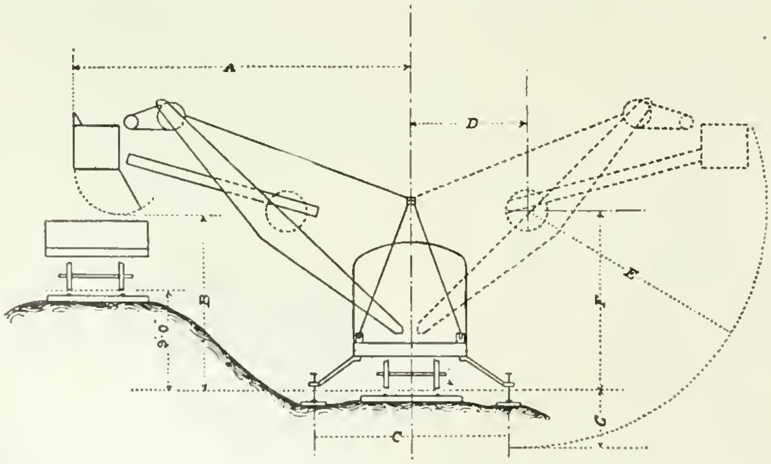


Fig. 13—Diagram Showing Lifts and Reaches of Steam Shovel.

Considering the many assumptions necessary in preparing the overhaul diagram on account of shrinkage and expansion, it would appear that the large scale diagrams are not offset by increased accuracy sufficiently to warrant their use, and that a diagram on the field profile (Fig. 6) will give the information to as great a degree of accuracy as the method warrants, besides being always available for giving the contractor his points for distribution of material on the ground.

By using the planimeter various methods of distribution can be easily computed. Set the index to read square inches and ascertain the area of diagram under balancing line drawn in accordance with the method noted above. This, multiplied by the proper factor according to scale (Fig. 6—2,000 cu. yds. to 1 in and 400 ft. to 1 in. = 8,000 cu. yds.) gives the total yards hauled to 100 ft. Ascertain area of free haul, and to this add the number of cubic yards hauled 10 stations. Subtracting these two from the whole area of diagram gives the pay overhaul.

With a small outfit, without variety of equipment, it often pays the contractor to waste and borrow (freehaul limit, 1,000 feet) rather than haul, the extra price for overhaul enabling him to do this. Care must be exercised, or one is apt to pay him for material wasted at his own expense.

[For a discussion on overhaul see Gillette's "Earthwork and Its Cost," Appendix B.—Editors.]

Road Crossings.—These, although relatively unimportant, yet having to be established on prescribed lines and at regular intervals, often occur in places where the quantities involved are considerable. Also as they frequently cross the roadbed at an oblique angle, a method of figuring them may be of service, although open to criticism from its being an approximation only.

Figures 7 and 8 shows a road crossing on a skew. M. N. P. Q., are the most important points to establish on the ground. P. and Q. should be laid out to give the requisite grade on road crossing between P.—Q. and the point S., otherwise the grade has to be steepened. Although a detail, this is often overlooked.

A (Fig. 7) is calculated from ordinary cross sections. Area of

$$Y = \frac{\text{Area } X}{\cos\theta}$$

B (Fig. 7) can be divided into two truncated triangular prisms, whose solidities are given by the following formulae: Area of right section × ⅓ sum of lateral edges.

C (Fig. 7) can be divided into pyramid and tetrahedron:

$$\text{Solidity of Pyramid} = \frac{\text{Area } X}{\cos\theta} \times \tfrac{1}{3}$$

(half breadth—½ roadbed).

Solidity of Tetrahedron = ⅓ depth at M × (half breadth—½ roadbed) × ½ roadbed of road crossing.

Grading Machines.—Figs. 9 and 10 are diagramatic plan and rear elevation of a grading machine, manufactured in Chicago.

This machine requires 42 ft. to work in, but has a 3 ft. extension section on the elevator, so that when required, this can be removed, making it capable of working in a 36 ft. cut. With sand or loose material, however, the extra height to which the elevator has to be raised to properly clear wagons, exceeds the workable angle of repose of the material, and it refuses to elevate.

With the short elevator the cut requires to be taken down very uniformly, or the wagons catch on the underside of elevator, even when used with one side board removed.

Working in a 36 ft. cut with a full length elevator, about 6 furrows in the center have to be thrown to the sides of cut and rehandled at a disadvantage, as the loose material will not throw a good furrow and is, besides, in the way of the wagons.

On the Medicine Hat section, in order to give the required width for these machines to work in, cuts were staked, as shown in Fig. 11, and in the cross-hatched section of Fig. 12. This increased the cut quantities slightly (as in Fig. 12 at ends of cut only), but the material being required in the fill, the overhaul only was increased. This cutting away of the toe of slope would be objectionable, if not impossible, in some instances, but here the banks caved back to a natural slope very quickly.

With six pairs of horses the machine could be turned in 36 ft by crowding, but to turn quickly more room is required.

With a cut, say 1,232 ft long, the lost time turning, at 2½ min per turn, amounts to 1 hour and 30 minutes per day, while the lost time ploughing furrows to waste for the lower 5/6 of cut was two hours. Whilst actually at work a wagon was loaded on an average every 65 seconds, including stop for next wagon. This gives an output for the main part of cut, 101 wagons = 505 cu yds per day, and for the lower 5/6, 307 wagons at, say, 1.25 cu yds = 384 cu yds per 10 hour day, which is a very poor showing for the number of teams required.

Whilst of great service in shallow borrow pit, street grading, and open work of that nature, this machine is all that is claimed by the makers, the writer is of opinion that money can easily be lost by trying to use it where boulders or hardpan are encountered, or where cuts are limited in width. Its chief drawbacks are: Too many delicate parts, frame not heavy or rigid enough, and consequently too much lost time for minor repairs, and as there is usually a big outfit waiting on account of the repairs, a series of short stoppages soon make a big loss.

[For a discussion as to the adaptability of grades to railroad work see ENGINEERING-CONTRACTING, April, 1906.—Editors.]

Steam Shovel Work.—Fig. 12 shows the diagram used to stake cuts for this work, giving equivalent quantities to the roadbed used, viz., 22 ft. slopes 1½—1. It is advisable to stake these cuts to a 1½—1 also, and cut a grip along this line to induce the bank to break back to the correct lines. If this is not done it breaks away in pockets.

Figure 13 will be found useful in determining what a given size of shovel will do, and enable one to lay out the most economical lifts which should be taken in making a thorough cut.

The question of water supply for the shovel, its quality and quantity should never be overlooked, as it materially affects the cost of the work.

The use of heavier steel than the dinkeys and dump cars call for is not economical, as it costs too much to move around and handle.

An all around shovel on traction wheels with a 1½ or 2-yd dipper, and 2½ yd. cars on 30-lb. steel would often be more serviceable than the heavier types of shovels, where the frequency and distance of moves is considered, and if it could be operated by a gasoline motor to solve the fuel difficulty, an almost ideal machine for railway work would be available.

A progress of 468 ft in 27 working days from April 1 to May 1, 1909, was made in the 16 ft diameter circular water supply tunnel known as the Southwest Land and Lake Tunnel for the city of Chicago. The material penetrated is limestone. This is a record of 17½ ft per day. The record from June, 1908, to May 1, 1909, has been 11¾ ft per day. The contractor for this work is Geo. W. Jackson, Inc., Chicago, Ill.

Lowering the grade of the portion of Pittsburg known as The Hump, or Grant's Hill, has reached the stage of an estimate of cost, prepared by the board of public works, placed at $1,165,000 for removing the hill, $300,000 for damages to street railways and $2,000,000 for damages to private property and contingencies, making a total of $3,165,000.

Roads and Streets Section

Note: This Section is devoted to methods and costs of road and street construction. It will cover road building in all its details, the construction of pavements, sidewalks and gutters, the testing and use of paving materials and the machinery and tools used in road building and paving.

The Theory of Economic Road and Street Design and Location.

(IV.)

Cost of Road Maintenance Per Ton-Mile.

So far as we are aware there are no printed records of the cost of highway maintenance expressed in the ton mile as the unit. All maintenance records of which we have knowledge are reduced either to the cost per annum per square yard of pavement or per mile of road. While it is desirable to use those units of area and length also, just as it is desirable to use the mile of track or roadway as a unit in railway engineering, it should be evident that the ton-mile is, by all odds, the most important unit to be used in solving problems in transportation.

It is fortunate that French engineers have so kept their records of macadam road maintenance that we can at least approximate the cost per ton mile on macadam roads. There are no published American data at all, so we would be forced, in any case, to use the French statistics. While it has frequently been said that the French data are of little use to American engineers, the statement is misleading. In determining what is the probable cost of maintenance of a macadam road subject to heavy hauling, the most uncertain factor is the amount of stone required to replace the wear due to a given ton-mileage of traffic. We are possessed of sufficient information to enable us to make an accurate estimate of the cost of scarifying an old road and the cost of placing new stone upon it and rolling it. Hence if we know the amount of new stone required, a close estimate of cost of maintenance of macadam can be made for any given conditions.

According to the French records it requires annually about 50 cu. yds. of broken stone (including 7½ per cent of binding gravel) per mile of macadam per 100 "collars" or "units" of travel per day, the stone having an average coefficient of wear of 11. This coefficient is about that of Niagara limestone, and indicates only a fair quality of stone. Hudson trap rock, for example, has about double this coefficient.

The "collar" or "unit" is one horse harnessed to a loaded vehicle. A horse harnessed to an empty vehicle or a private carriage is rated as ½ "collar." If we assume that the average load hauled on macadam by one horse is 1¼ tons then the 100 "collars" per day over each mile are equivalent to 100 x 1¼ x 365 = 45,625 ton miles during a year of 365 days. And since 50 cu. yds of broken stone are required to repair the wear due to this traffic, we have 50 ÷ 45,625 = 0.0011 cu yds of loose broken stone required for each ton mile. Since it takes 1.6 cu yds of loose broken stone and screenings to make 1 cu yd of packed macadam, it follows that there are 0.0011 ÷ 1.6 = 0.0007 cu yds of macadam worn out by each ton mile of traffic. It must be remembered, however, that empty wagons are regarded by the French engineers as being equivalent to half loaded wagons. This is a satisfactory way of regarding the effect of wear, but it would be confusing for our present purpose. If we assumed that the vehicles go loaded to market and return empty, then the 100 "collars" above referred to would mean 66⅔ horses pulling a loaded vehicle (or 66⅔ "collars") and 66⅔ horses pulling an empty vehicle (or ½ of 66⅔ = 33⅓ "collars"). Therefore the true number of tons per 100 "collars" would not be 125, as above assumed, but two thirds of 125. Hence our 0.0007 cu yd of macadam worn out by each ton-mile should be divided by ⅔, which gives 0.001 cu yd of macadam per ton mile of actual loads carried, considering all empty vehicles as having no ton miles to their credit.

While the foregoing deduction may be criticised for the assumptions upon which it rests, it must be conceded to be approximately correct for ordinary macadam subject to the traffic of steel tired vehicles. We are not now considering the effect of pneumatic tired vehicles, which destroy macadam not by abrasion, but by displacing its component pieces.

Having arrived at a tolerably close estimate of the wear of macadam under farm wagon traffic, it remains only to estimate the cost of repairing the macadam from time to time.

Continuous repairs on roads not subject to heavy traffic are as absurd as it would be for a man to hire a tailor to accompany him so that any slight rip in his clothes could be sewed up the instant it occurred. It might well pay a large body of men to have such a tailor always at hand, for he could then be kept reasonably busy. The "stitch in time" theory of road repairing is founded on fallacious reasoning unless there is enough traffic to keep the stitcher busy.

Repairs on roads subject to light traffic should be intermittent, and when thus made the cost of maintenance is slight. The writer has found that when macadam has worn to such an extent that about ½ in. to 1 in. has been abraded from its entire surface, there will have developed a sufficient number of irregularities in its surface to make an entire resurfacing desirable. Then the surface should be scarified (harrowed) to a depth of 3 ins., enough new stone should be spread over it to replace the material lost by wear, and, after leveling the surface, the road should be sprinkled and rolled.

The cost of scarifying macadam is about ¾ ct per sq yd. (See ENGINEERING-CONTRACTING, Oct. 28, 1908, and Gillette's "Handbook of Cost Data," page 151 et seq.) Rolling and sprinkling costs another ¾ ct per sq yd, making a total of 1½ cts per sq yd. If this resurfacing is done when the macadam has worn down ½ in., it is evident that each square yard of resurfacing will require one seventy second part of a cubic yard of new macadam. Hence the labor of placing and compacting this new macadam costs 1.5 cts × 72 = $1.08 per cu yd of new macadam. If the broken stone and screenings can be delivered on the road for, say, $1.50 per cu yd, and if it takes 1.6 cu yds of the loose stone and screenings per cubic yard of macadam, we have a total cost as follows per cubic yard of new macadam rolled in place:

	Per cu yd
1.6 cu. yds. stone at $1.50	$2.40
Scarifying, spreading, sprinkling and rolling	1.08
Total	$3.48

The writer has made repairs at this cost where the steam roller cost $1 per hour.

We have seen that it requires 0.001 cu. yd. of macadam to repair the wear due to each ton-mile of traffic. Hence, assuming as high a cost as $4 per cu. yd. of new macadam (instead of the $3.48 above estimated), we have 0.001 × $4 = $0.004 per ton-mile as the cost of maintaining macadam subject to farm team traffic, the stone having a coefficient of wear of 11. In brief, the cost of maintenance of the macadam is 4 mills per ton-mile.

In this connection it may be interesting to note that the cost of maintenance of way and structures averages 1½ mills per ton-mile for American railways, of which about 1 mill is for maintenance of roadway, ties and rails.

The above estimated 4 mills per ton-mile applies only to the macadam. On all roads there is some expense involved in repairing the earth wash due to rains, the cutting of weeds, the cleaning of culverts, the repairing of bridges, etc.; but such maintenance is common to all roads, whether paved or unpaved, and need not be considered in solving problems of economic road pavement design.

The effect of rapid revolving pneumatic tires is exceedingly severe on ordinary macadam, and it will be necessary in the future either to build special roads for rapid motor car traffic or to adopt some other binder than stone dust for macadam wherever the amount of motor car traffic is at all large. No statistics are available for determining what the added cost of maintenance will be on a road subject to motor car traffic. At present, therefore, we must confine ourselves to the subject of maintenance of paved roads designed for steel tired traffic.

The effect of changes of temperature, the leaching action of water that falls upon the broken stone, and the like, have never been scientifically ascertained. In England it has been said that of the total cost of maintenance 20 per cent should be charged to "atmospheric agencies." This is a mere guess and doubtless gives far too great weight to this factor.

The effect of horses' hoofs has been variously estimated. On brick, stone block and asphalt pavements hoofs have comparatively little effect in causing wear. This is well illustrated on streets where horse cars have been used for years. On one street in New York, where loaded trucks follow the car tracks with one wheel on the rails and one wheel on the pavement, deep ruts have been cut into the granite blocks, while the blocks between the rails remain in good condition although subject not only to the wear of the truck horses but to that of the horses hauling street cars.

While broken stone roads differ in that horses' hoofs are apt to displace stones occasionally, it can not be denied, we think, that practically all the wear is due to the emery action of the stone dust under the wheels.

[The next issue will contain a summary of the itemized costs of (1) hauling, (2) maintenance and (3) interest per ton-mile, from which will be deduced a rule to be used in determining the expenditure that is economically justifiable, in any given case, for paving an earth road with broken stone or with some other hard and durable surface.]

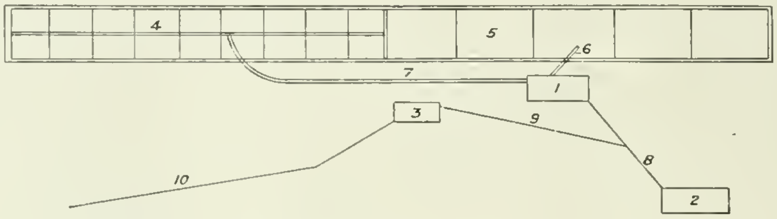
The first lot of 300,000 concrete railway ties used by the Italian State Railways proved so satisfactory that a similar lot has been ordered. The ties cost $1.48 each in Italy.

Some Novel Methods of Sewer and Street Construction on Reclaimed Land.*

The property in question was 7,950 ft. long, and from 680 to 3,470 ft. wide, bounded on the east by the Atlantic Ocean, on the west and south by Turtle Gut Inlet, and on the north by the city of Holly Beach, N. J. It was covered with a depth of 3 ft. of water at high tide. Upon examination it was found to consist of a thick black mud, covered with heavy meadow sod, some rank growth, and irregular mounds of sand, which, owing to the currents, were constantly changing position.

As speed was to be essential in the entire undertaking, it was decided to do all work on force account, and with this end in view plans were at once commenced for raising the grade 4 ft. and maintaining it at that level.

The method adopted in this filling was the use of two hydraulic dredges, one dipper dredge, ten scows, and a small, but powerful tug, with the necessary discharge pipe, etc. The hydraulic dredges were about 90 ft. long and 32 ft. wide, containing a centrifugal pump of 22-in. suction and 20-in. discharge; the dipper dredge had a capacity of 3 cu. yds.



SKETCH SHOWING LAYOUT OF PLANT.

1.- Centrifugal Pump and Engine on truck. 2.- Boiler. 3.- Piston Pump
4.- Trench with pipe laid ready for filling. 5.- Trench ready for excavation.
6.- Suction pipe. 7.- Discharge pipe. 8.- Pipe boiler to engine.
9.- Pipe, boiler to pump. 10.- Pipe to water supply.

Fig. 1—Lay Out of Plant for Excavating and Backfilling Sewer Trench.

Owing to the rise and fall of the tide covering the base of operations, provision had to be made for the protection of the sand after having been deposited, and with this purpose in view a light bulkhead was constructed around the entire property, same being completed in sections as fast as the filling progressed.

On the completion of the dredging and bulkheading we were now ready to proceed with the other improvements, and three corps were placed in the field—one to lay out the streets and give grades and levels; the second to lay out the sewer system and water mains and to give locations for telephone ducts and railroad; while the third had the location of building and lot lines, sidewalks and grades.

It may be well to mention at this point that on the two main streets, instead of having one large sewer in the center of the streets as is customary, two smaller sizes were laid under each sidewalk; while between the sidewalk line and the property line in a strip 8 ft. wide that had been reserved for this purpose were located the water and gas mains, telephone and electric conduits. The reason of this change was that it was proposed to lay a vitrified block pavement, one of the features to be permanency, which could not be had if every public service corporation that desired could rip up the pavement and replace it in any half-hearted way that they chose; and from investigations that had been made it was found that if success were attained in getting the pavement down at all, it would not be in such a way that it could be tampered with.

To serve the buildings a system of terra cotta pipe sewers were built. The trench for the entire distance, 16 miles, was through quicksand, known locally as "boiling sand." This was both expensive and difficult work, as it was difficult to keep the pipes in proper grade and alinement, and the joints were hard to calk, owing to the water in the ditch.

The greatest cutting was 6½ ft. deep, and the entire trench was double sheeted throughout, great trouble being experienced in keeping the trench even partially dry. Sumps or wells could not be made, as the pumps pulled out so much sand under the sheeting as to cause the ditch to either fill or the sheeting to cave in. Water was struck 12 in. below the sand grade in great quantity.

The sheeting was put down to a depth of 10 ft. with a water jet in advance of the excavation, this being the only way that any headway could be made. Owing to the numerous "salt holes" encountered, it was necessary to make a foundation for the manholes and pipe. This was done by piling spaced 7 ft. apart and 6 in. center to center. On the piles yellow pine timbers 4x4 in. and 8 ft. long were spiked, and to these were spiked hemlock planks 2x8 in. and 14 ft. long. The pipe was laid on this and the hole filled with sand and salt hay.

If a manhole was located at one of these "salt holes," four piles 10 to 15 ft. long were driven, 4½ ft. center to center. Four railroad ties were then spiked together with two battens, and the whole bolted securely to the piles. On this foundation was placed a box 5 ft. square and 10 in. deep, the bottom being covered with tongue-and-groove floor boards, and in some cases lined with canvas and the inside coated with hot coal-tar pitch. The concrete was placed in the box, the pipe line run through inverts struck, and the brickwork completed.

The method of excavating was as follows: By using the piston pump the sheathing was put down for a distance of 150 ft. along the trench, and closure made at each end. Then ten laborers were put in the trench and excavation made to the water line, when rangers and braces were set.

The piston pump was then started pumping water into this "land coffer-dam." A centrifugal pump was moved in position, and the discharge pipe placed midway in the last section where the sewer pipe had already been laid. Thus the centrifugal pump excavated the material from the forward section and backfilled the last section at the same time.

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*Extracted from a paper by Geo. L. Watson read before the Canadian Society of Engineers April 15, 1909.

When grade was reached the foundation piles were jetted down and the cradle constructed. The pipe was then laid, the joints being made with neat cement and boiling tar, as this was found, after experiments, to be superior to sulphur, cement, asphalt, or sulphur and sand. The next section was then done in a similar manner.

The sand excavated was quite coarse and but little agitation was necessary with shovels, in order to allow the pump to pick up the sand. When the sand is fine grained much more water is needed, and likewise the sand must be agitated with shovels. With extremely fine sand the men must be relieved frequently, as the work is hard, and the pump taking up a much smaller percentage of the sand, means the ditch must be kept with a larger amount of water in it, and the men, being compelled to stand in the water, feel the effect of it quickly.

At times when we got as deep in the trench as the original grade line, we encountered roots and stumps that had to be cut out, but this was seldom necessary.

Fig. 1 shows the layout of the plant to do the work in the manner described. In this way 300 lin. ft. of trench was dug and pipe laid, per day, while on similar work under the same conditions in Holly Beach a contractor made but from 35 to 50 ft. per day, doing the work by another method.

Very little trouble was experienced in laying the water and gas mains, as these were but 2 ft. deep, and on all but two principal thoroughfares were located in the center of the street. Fire hydrants were located on a radius of 600 ft. from one another, and but two electric light and telephone poles were allowed to each block of 500 ft.

The sidewalks were of cement and but 3 ft. wide, and these, as well as a concrete curb, were placed as soon as the sewers, gas, water, telephone and other wire conduits were laid, after which provision was made for ballasting the streets.

Two spurs of the railroad were extended temporarily through the property, and with a plant of 80 carts, 3 road graders, 7 steam rollers, and 200 men, the work of grading 16 miles of streets commenced. The roads and streets were finished with a 9-in. coat of Burleigh gravel, and no provision was made to carry off the storm water owing to the permeability of the soil, but the grade was broken and towards two shed lines, where sumps were located that were connected with the main outfall sewer. The trolley line was then extended through the property on the main streets and operations commenced for laying the pavement.

It was contended by many who were familiar with the then existing conditions that it would be next to impossible to secure a satisfactory foundation for the pavement, owing to the fact that three months previous the street was nearly marsh covered with "sponge" and "salt holes." Previous to starting the construction, notice was served upon all parties concerned that digging up the new pavement for any cause whatsoever would not be tolerated. The pavement proposed was a vitrified block on a 6-in. concrete foundation. When test holes were opened, water was found 12 ins. below the surface, and in numerous places a running or boiling sand was encountered. This of course necessitated a different method of procedure than had at first been anticipated.

By means of a jet, creosoted piling 6 ft. long and 12 ins. at the butt were pumped to 12 ins. below the ties of the trolley line 6 ft. apart, directly under the rail, for the entire length of the line. A trench was then excavated along the line of the piling, and concrete beams 6 ft. long, 12 ins. wide, and 12 ins. deep, reinforced with ¾-in. twisted steel bars and projecting stirrups were molded in place on the piling. At the curb lines on either side of the street, and between the curb lines and the rail on each side, a line of piling was placed similar to that under the rail with the exception that proper allowance was made for the grade and crown of the street.

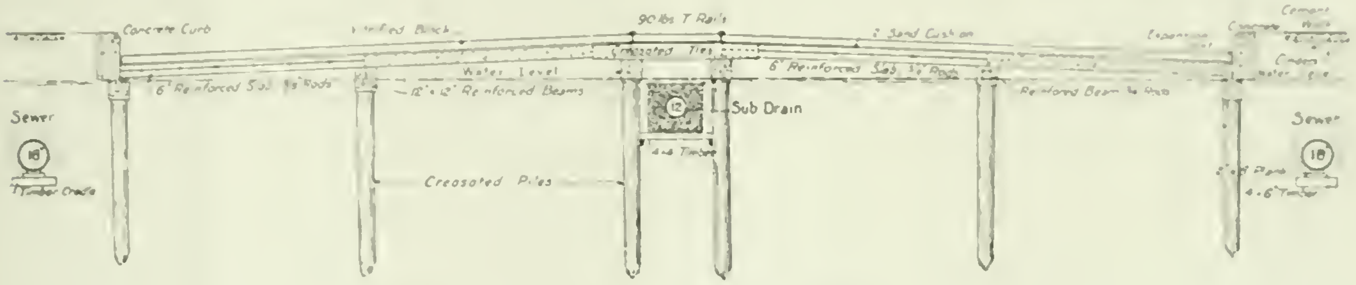

Fig. 2—Transverse Section of Reinforced Concrete Base for Brick Pavement.

Upon these beams (for a like beam was placed upon all the piling) a 6-in. reinforced concrete slab 10 ft. long and 6 ft. wide was placed, the reinforcement consisting of ⅜-in. steel rods interlaced and wired. It took two slabs to reach from curb to rail. The concrete slab under the rails was finished in a similar manner, the ties resting directly upon the beam, the slabs being notched for the ties.

At frequent intervals underdrains were laid connecting with the nearest manhole, and in some places the flow of water was so great as to necessitate a permanent sump being built under the foundation. This underdrain was composed of 12-in. terra cotta pipe laid with burlap joints with gravel casing in a box crib resting upon stringers spiked to the piling every 6 ft., and discharging into the trunk sewer.

A 2-in. sand cushion was then placed on the concrete foundation, after which the bricks were laid and the whole grouted. Expansion joints were placed along the curb alternating every 200 ft.

Six months after completion it was decided to extend this pavement for another thousand feet, and when excavations were made it was somewhat of a surprise to see that the sand had receded from its position against the slabs, and was now 18 ins. from them, and that water was flowing [illegible] under the principal streets of the town and has continued to do so to date.

The city and county of San Francisco, Cal., is to begin work this year on the construction of a new $4,000,000 sewer system, and a $5,200,000 auxiliary water supply system for fire protection.

Experimental Road Work by the Massachusetts Highway Commission in 1908.

The Massachusetts Highway Commission was among the first to recognize the changed conditions of macadam road construction resulting from the increased use of motor vehicles. During the past few years the Commission has conducted many experiments to determine the best methods of [illegible] from [illegible] amount of damage to the roadways, and also to prevent the dust which is raised by automobiles from becoming an intolerable nuisance. In its annual report for the year ending Nov. 30, 1908, the Commission describes the work done during that year, and the matter in this article has been taken from advance sheets of that report.

The experiments of the Commission were divided into two groups: the temporary laying of dust and the partial and temporary preservation of road surfaces; and the employment of some new material as a binder in the construction of the roadway which will enable the road to withstand automobile travel and without excessive dust.

TEMPORARY DUST LAYERS AND ROAD PRESERVATIVES.

In 1908 the Commission repeated and extended the experiments of the previous year in the use of various dust layers and various materials to temporarily preserve road surfaces, more than 75 miles of road being so treated.

Nearly 23 miles have been treated with Texas oil, at a cost varying from 5 to 7 cts. per sq. yd. Liquid asphalt was used on 10.22 miles at a cost of about 6¾ cts. per sq. yd. Tarvia B was used on 22.1 miles at a cost of about 4 cts. per sq. yd., including covering. [illegible] was used on 1.2 miles, at a cost of 5¼ cts. per sq. yd. Asphaltoilene was applied to 1.5 miles, at a cost of 6 cts. per sq. yd.

The processes, in general, were substantially the same and consisted in cleaning the road surfaces of all dust down to the stone, spreading the bituminous materials, in some cases cold and in some cases hot, according to their consistency, allowing them to soak in for a time, then covering with clean sand or gravel or stone screenings to absorb the surplus material and to provide a wearing surface on the road. The costs varied according to the haul and other local conditions, the bituminous materials being nearly uniform in price.

Judging by the experiments of two years, it can be said that these various materials lay dust very satisfactorily and prevent roads from raveling to a great extent. The results have varied in places, and this has been due, in the opinion of the engineers and other observers, to the fact that there were dust pockets, or places where the material used did not penetrate to the stone beneath, or the stone was not thoroughly compacted, but was loose, and the top surface, therefore, scaled off. If the patches that have scaled are not treated very soon, large depressions quickly form where there is much automobile travel.

In general, with any of the bituminous materials mentioned, satisfactory results were obtained if sufficient care was used in doing the work. The effect of these treatments has, so far, in some places largely disappeared by the following spring, but where a road was in proper condition, it has prevented any serious raveling during the season.

Calcium Chloride and Oil Emulsion.—Calcium chloride was used upon four miles of State highway in Beverly, being paid for by the residents upon the shore. It laid the dust in a very satisfactory manner, and somewhat preserved the road surface,—better than proper watering would have done. The road, however, has developed some small holes and depressions, and has had to be repaired twice during the year and small quantities of stone added, although it is only from two to three years old. Automobile and team travel is very heavy upon this road. During the season of five months six applications of calcium chloride were put on, and the cost for the spread of the cart (about 17 ft. wide) was $289 a mile for the season.

Upon a mile of State highway in North Beverly, which had been newly resurfaced, oil emulsion was used, the cost being defrayed by one of the abutting owners. The treatment was started late in the season, so that the cost for the year could not be determined.

A soft naphtha soap was used to emulsify the oil, 20 lbs. of soap being mixed, by an ordinary pump, with 50 gals. of water and 100 gals. of Texas oil. The emulsion was then put into a watering cart, the water turned on from a hydrant, under pressure, with a hose pipe, until the cart was filled, and then the mixture was immediately spread upon the road. It was found that with one watering cart of 600 gals. capacity about ⅕ mile of road could be covered, and that the materials cost $30 per mile for each application, for the spread of the cart. As there was considerable dust upon the road, a second application was necessary within a week, and a third at the end of a month, but the dust was satisfactorily laid for about three months, or until snow fell.

Both calcium chloride and oil emulsion require several applications during a year, probably from four to six, to produce satisfactory results, and with calcium chloride the road has to be watered once a day during the dry season, but, speaking generally, the results produced are much better than those obtained when an ordinary watering cart and water alone are used, and the expense is no greater than the cost of watering, because one cart can take care of as many miles of road as three carts can when water alone is used. The saving in the cost for teaming, etc., will just about pay the cost of the calcium chloride. The chief advantage in the use of this chemical lies in the fact that the dust is satisfactorily laid during the whole day of 24 hours. The same is probably true of oil emulsion, but neither these materials nor the ones mentioned above are more than temporary dust layers and road preservatives, as the effect is almost if not entirely lost by the following spring.

NEW CONSTRUCTION WITH VARIOUS BITUMINOUS BINDERS.

The commission has conducted a number of experiments in several places in order to find, if possible, some method of road construction which will prove satisfactory, both for automobiles and for horse-drawn vehicles.

A number of these experiments have been tried to determine whether, if bituminous binders are to be used, it will be sufficient to adopt the penetration or grouting method in the upper course after the stones are laid and partially rolled, or whether the stones for the top 2 or 3 ins. of the road must be coated before they are spread upon the road.

A number of experiments were made in Wenham, where the State highway was being resurfaced. The old road was first picked up and shaped, then No. 2 stone was spread and rolled. The bituminous material was then heated in a large, movable kettle, spread evenly upon the road, broomed to secure the most even coating possible, and allowed to penetrate into the interstices between the stones. All travel was kept off the road.

The road was then rolled and covered in different sections with top-dressings of sharp sand, clean gravel, pea stone, or sand heated and mixed with tar and brushed on the road so as to fill all the interstices remaining after the grouting.

In general, sections were built 100 ft. in length, and were divided into three parts, using upon the first materials obtained from the American Tar Co., on the second those obtained from the Barrett Manufacturing Co., and on the third various asphaltic oil and residuum oil products obtained from the Gulf Refining Co.

Tar Grouting.—These materials were heated when that was necessary, spread upon the road, brushed in and covered. In some of the tar sections a flush coat was painted upon the top of the road. A little less than 2 gals. of bituminous material to the square yard of road surface were used, and the tar was mixed in various proportions with pitch, and, in some cases, with residuum oil asphalt.

Oil and Asphalt Grouting.—In the oil and asphalt section the material was prepared and spread in the same manner, and was mixed in various proportions, using, in some cases, a so-called fluxing oil (a residuum asphalt oil) and proportions of equal quantities of asphalt and fluxing oil, to three parts of fluxing oil and one part of asphalt.

Water-gas Tar Grouting.—Short sections were treated with water-gas tar, which did not prove satisfactory, nor did a mixture of asphalt and water-gas tar. These sections were, therefore, re-treated.

Costs.—The cost for shaping, picking up and putting on No. 2 stone, at an average of 18⅓ tons to the 100 ft., was $0.315 per sq. yd.

The cost of the bituminous materials, labor, heating, spreading, and the sand, gravel or pea stone used on the top in the sections of road built of tar, varied from $0.184 to $0.213 per sq. yd.

In the asphalt section, where tarvia and asphalt were used, the cost for the bituminous material, labor and top covering was $0.292 per sq. yd.

A short section which was built with an oiled sand top cost $0.417 per sq. yd. This work was similar to that done at Wareham, which will be discussed later.

In considering the costs, it must be remembered that they were excessive for several reasons; one because the work was done late in the year and the sand had to be heated. The second and more important reason is that in changing from one material to another in each 100-ft. section the work had to stop, the kettle had to be emptied and the fire drawn before the new materials which were to be used could be heated, and there was necessarily a large waste in labor while the men were waiting for the new material to heat.

Tarvia Grouting at Westminster.—A much more reliable estimate of the cost of this kind of work can be deduced from the Westminster experiment. There a macadam road, 9,836 ft. in length, built as a State highway between the years 1894 and 1899, was much worn. Not any of the upper course remained, and in places the stone had been worn through to the road foundation.

After picking up and shaping the old surface, No. 1 stones, varying in size from 2½ ins. to 1¼ ins., were spread to a width of 12 ft., so that the upper surface of this course should be 1½ ins. lower than the proposed finished road surface, and so as to produce a crown of ¾ in. to the foot, using, in all, 1,492.2 tons of trap rock (15.17 tons per 100 ft.) in this course. The No. 1 stone so spread was rolled thoroughly with a 12-ton roller, and all of the voids were filled with a sandy gravel, but no surplus gravel was allowed to remain on top of the course.

No. 2 trap rock (1¼ ins. to ½ in.) was then spread on in an even layer to a width of 15 ft. and to such a depth that, after rolling, the course should be 1½ ins., thick, 934.16 tons (9.497 tons per 100 ft.) being required. This course was rolled until its surface was at the required cross-section and until it was moderately compact.

Tarvia, graded as No. 5 by the Barrett Manufacturing Co., was then applied. Here, as at Wenham, the tarvia was heated in large, portable kettles to about 180° F., and was then flowed upon the stones by means of a hose having a flat nozzle, and distributed as evenly as possible at the rate of about 1 gal. to the square yard of surface. After a few hours the road was covered with dry, coarse sand up to pea size, rolled thoroughly, and some excess sand left upon its surface.

The road picked up in places before the work was completed, and as an examination of some of the loose stones showed that they had not been completely coated with the tarvia, the commission increased the quantity of tarvia from 1 to 1¾ gals. per square yard on the remainder of the contract.

The cost of the work was as follows:

2,426.36 tons of broken stone, including picking up and shaping old surface, gravel binder, and all incidental work and materials, at $2.30	$5,580.63
12,083 sq. yds. of tarviated surface, at $0.11	1,329.13
4,310 sq. yds. of tarviated surface, at $0.19	818.90
Total	$7,728.66
Sq. yds. resurfaced	16,393
Cost per sq. yd.	$0.471
Tons of stone per 100 ft.	24.667

While the foregoing costs are contract costs after competitive bidding, and are not taken from the contractor's pay rolls and vouchers, it is known that there was little or no profit to the contractor on this work. In fact, he has stated that he came out about even. At the end of the season the road was in good condition, and all the surplus sand left upon it had either combined with the tar or blown off.

Bituminous Macadam at Hamilton.—The commission, at the request of the selectmen of the town of Hamilton, constructed a small section of bituminous macadam road on the main street at Hamilton station, a part of it being paid for by the Boston & Maine R. R. Co.

This was new construction. The roadbed was carefully prepared with a subgrade of good gravel, and graded according to cross sections. Upon this was laid a 4-in. layer of No. 1 stone, thoroughly rolled. A coating of coarse sand was then added, flushed with water and thoroughly rolled, using about 1 cubic yard of sand to every 12 sq. yds. of road surface in order to fill the voids, so that the tar, to be applied later, should not go down into the lower course of stone. Upon this was laid a 2-in. layer of No. 2 stone, which was coated with tarvia No. 5, secured from the Barrett Manufacturing Co. It was all mixed by hand upon a dumping board, the stone being turned from two to seven times. About 11.3 gals. of tarvia were used for each cu. yd. of stone, and several mixtures with tar, pitch and asphalt were tried, but the tarvia was found to be satisfactory. On a portion of this work pea stone was mixed with the No. 2 stone, in an attempt to more completely fill the voids. After the stone had been coated, placed upon the road and rolled, a flush coat of No. 3 tarvia was spread upon the surface, and in some cases tarvia mixed with pitch, using from ¼ to ½ gal. of tar to the sq. yd. of road surface. This was covered with sharp sand in some places and pea stone in others, and rolled three or four times to fill all the voids. While the tar ran out a little during the hot weather and additional sand had to be added, and a few slight depressions appeared, these all filled up again, and the road is now in satisfactory condition and shows no sign of wear.

There were 2,436 sq. yds. in all built in this manner. The work was necessarily expensive because such a small quantity was done, and various experiments were tried. The total cost, including all stone, shaping, grading, etc., was a little under $0.71 per sq. yd.

The cost of the tar, mixing, etc., for the course of No. 2 stone was $0.22 per sq. yd., and the cost of the stone was $0.111 per sq. yd. The cost of the flush coat put on top, including the tar, etc., was $0.056 when sand was used, and $0.068 when pea stone was used, per sq. yd. This makes an additional cost for the use of the bituminous macadam rather than ordinary macadam of from $0.27 to $0.28 per sq. yd. Undoubtedly these costs would be reduced from 25 per cent to 30 per cent on a good-sized piece of work, and still more, perhaps, if a mechanical mixer were used.

RESURFACING WITH SAND AND ASPHALT OIL MIXTURES.

The commission has tried several experiments in resurfacing old macadam roads with various bituminous materials mixed with sand and spread upon the top of old roads. In this work the old surfaces were picked up and shaped, so as to bring them to a true crown and grade. A layer of bituminous material and sand was then placed to a depth of about 2 ins. in the center and 1 in. at the sides.

In Wenham there were 316 sq. yds. treated in this manner, using on the first 100 ft. a mixture of oil asphalt and fluxing oil in equal quantities, and fluxing oil alone on a second section. Both products were heated to about 180° F., and the sand was heated also, as it was late in the year, and the mixture was then spread upon the road, as above stated.

On the first section, 26 gals. of mixture were used to every cu. yd. of sand, and on the second section, 17½ gals. The average cost of these two sections treated in this manner was $0.462 per sq. yd. This cost was considerably less in the section where fluxing oil alone was used, as the quantity used was only 1 gal. to the sq. yd. of road surface, whereas where the asphalt and fluxing oil mixture was used it was nearly 1½ gals. to the sq. yd. Also, the price would be much less (especially in using fluxing oil alone) if the work were done in warm weather, when the sand did not have to be heated.

In Wareham, near Tremont station, the same kind of experiment was tried upon a macadam road. The materials for use there were furnished free of charge by the companies and individuals dealing in the same.

On the macadam road, when necessary, it was shaped; otherwise it was brushed as clean as possible, and generally a light coating of the material that was to be used in the mixture was spread upon the clean road before the mixture was applied. In one or two instances, where this was not done, the top coat had a tendency to peel off and separate.

In general, the mixture was made of the bituminous material and sand, both being heated and mixed upon a dumping board, and then spread upon the road in sufficient quantities to produce a coating 2 ins. thick in the center and 1 in. thick on the sides. This was then rolled with a light roller, weighing about 200 lbs., and later with a roller weighing 700 lbs., and thoroughly compacted. Travel was kept off for several days.

A section 325 yds. in area was treated with tarvia B, furnished by the Barrett Manufacturing Co. Here the quantity used was a little less than ½ gal. to the sq. yd. This mixture hardened very slowly and did not seem to bind very well, although it improved in condition somewhat in ten or twelve days, until it began to freeze. Since then the condition has been rather poor. About 300 yds. were treated with tarvia A, furnished by the Barrett Manufacturing Co. Here ¼ gal. per sq. yd. was used in a wash coat, and about ½ gal. per sq. yd. with the mixture. The coating here was about ¾ in. in the center and ½ in. on the sides, after rolling. This material began to harden in about three days and was quite well bonded in ten days. It broke up a little when it first froze, but is still in fairly good condition.

The next section treated was 261 yds., where petroleum road oil No. 4, furnished by the Standard Oil Co., was used. Here, including the wash coat, about .87 gal. was used per sq. yd. At the end of a week there was not very much bond, but at the end of two weeks it had improved, and was in fair condition, although somewhat loose in the horse path, but well compacted where the wheels went over it.

The next section was 137 sq. yds., where asphalt macadam binder No. 8, furnished by the Standard Oil Co., was used, the section being 2 ins. thick in the center and ¾ in. thick at the sides. Here .92 gal. was used for each sq. yd. of surface. The weather was quite cold when this was put on, but it began to harden in one day, and when travel was turned on, in two or three days, it was hard enough to hold it up. It is still in good condition.

The next section was 130 sq. yds., which was treated with fluxing oil, furnished by the Gulf Refining Co. (This is a residuum asphalt oil, which has to be heated.) Here, including the wash coat, 1.12 gals. were used for each sq. yd. The depth of the sand and oil mixture was 2 ins. in the center and 1 in. at the sides. This material hardened in one day and has been in excellent condition ever since.

The next section treated was 125 sq. yds., where asphaltoilene, furnished by the Good Roads Improvement Co., was used, 1.36 gals. being used for each sq. yd. of surface, including the wash coat. When travel was turned onto it, in two or three days, it had not hardened appreciably, and it is still somewhat loose, and ruts.

The next section was 155 sq. yds., treated with fluxing oil and "A" asphalt in equal parts, procured from the Gulf Refining Co. A section 2 ins. deep in the center and 1 in. deep at the sides was put on, using 1½ gals. to the sq. yd. This material hardened very rapidly, with very little rolling, and in twenty-four hours held up travel without rutting. It is still in good condition. The next section was 76 sq. yds., treated with fluxing oil three parts and "A" asphalt one part. The coating was of the same thickness, and 1.2 gals. of the mixture were used for each sq. yd. of surface. This also hardened rapidly, and within 24 hours held up travel, without any indication of rutting, and is still in good condition.

The next section treated was 56 sq. yds., where a light liquid asphalt was used, furnished by the Indian Refining Co., about 1½ gals. being used to the sq. yd. of surface. Travel was allowed over this section on the day it was applied, and it rutted slightly, but soon smoothed out and is now in good condition. The next section treated was 63 sq. yds., where heavy liquid asphalt, provided by the Indian Refining Co., was used, about 1½ gals. being used to each sq. yd. of surface. Travel was allowed over this section the first day, and slight ruts formed, but these soon smoothed out and the surface is now in good condition.

In the next section, 90 sq. yds. were treated with Texas oil, furnished by the Texas Oil Co. Here 1.4 gals. were used for each sq. yd. This oil would run out of the barrel without being heated. Travel was allowed over this section of road on the same day that the mixture was applied, and, while it rutted a little in the beginning, it has since smoothed out and the surface is now quite smooth and in good condition.

Costs.—The cost of these different sections varied greatly, according to the materials used, the quantity, thickness of section, etc. The tars and oils were donated. As a rough estimate of the probable future cost of such work it can be stated that the total cost for labor, heating, grading, sand, mixing, spreading, rolling, etc., was from $0.115 to $0.22 per sq. yd. (not including bituminous materials). This cost can probably be nearly, if not quite, halved on good sized pieces of work. The tar and oil products will probably cost from $0.045 to $0.09 per sq. yd.

In general, it should be noted that in these experiments, as in those at Wenham, the cost is excessive because of the late season of the year, and because, with all the materials, the sand had to be heated and mixed upon a dumping board, then placed upon the road. This is also true of experiments with oiled roads, which are mentioned below. With some of the materials it will probably be necessary to heat the sand at all seasons of the year, but with many others, the bituminous material, whether tar or oil, is all that will have to be heated, and it can be spread upon the sand in hot weather. It is probable, also, that a very large saving in cost can be made, when it has been determined what materials to use, by the use of some mechanical mixer similar to some of the concrete or asphalt mixers, particularly the ones with a double blade.

BITUMINOUS BINDERS FOR SAND ROADS.

The commission conducted a number of experiments in the fall of 1908 in Wareham, using the same materials mentioned above, which were furnished, free of cost, by the manufacturers and dealers. These materials were used in building sections of road where nothing but a mixture of sand and the oil or tar binder was put upon the road. The road selected was near Tremont station, was well drained, required but little grading, but was an ordinary Cape Cod sand road.

The oils and tars used were heated in a small kettle to about 200° F. Sharp sand was heated on the side of the road, and all moisture expelled. Where oil and asphalt were used it was found necessary to heat them in separate kettles, as the asphalt required more heat than the oil.

The oil or tar and sand were mixed by hand upon platforms, the mixture being turned four or five times. It was then spread upon the prepared surface, about 4 ins. deep in the center and 3 ins. on the sides. Soon after spreading, the surface was rolled with hand rollers, weighing from 250 to 700 lbs. each, and travel was kept off for one day to one week, as seemed necessary.

The total costs of the work, including a small amount of grading and some shaping, but not including the cost of any of the bituminous binders, which, as before stated, were all donated, varied from $0.30 to over $0.60 per sq. yd. The binder used varied in quantity from 1½ gals. to 2¾ gals. per sq. yd. It seems probable that these costs may be cut at least in halves when any considerable length of road is constructed. The engineer who had charge of the experiments estimates that with some of the materials a fair cost would be from $0.20 to $0.25 per sq. yd., including the bituminous binder and all other materials and labor.

In general, the widths treated were from 15 to 18 ft., as this width seemed necessary in order to prevent travel from turning out onto the sand and thereby shearing off the shoulders.

The first section treated was 118 ft. long, and was treated with tarvia B. On 236 sq. yds. was placed an application of the mixture 3½ ins. deep in the center and 3 ins. deep on the sides. Here 1⅓ gals. of tarvia were used for each sq. yd. The surface did not harden appreciably for about ten days, and the road was rolled occasionally and travel kept off for two weeks. When travel was first put on the surface rutted considerably, but afterward improved rapidly. It also broke up a little under frost, but has improved since, and, while not as satisfactory as the section treated with tarvia A, it is in reasonably good condition. The next section was 180 sq. yds., where 1.85 gals. of tarvia A were used to each sq. yd. of surface. The surface commenced to harden in two or three days, and travel produced very little effect on it. It has been in good condition ever since.

Petroleum Road Oil No. 4, a light asphalt residuum oil furnished by the Standard Oil Co., was used, 270 sq. yds. of road being treated, using 1.63 gals. of oil to the sq. yd. When travel was put on, in about ten days, it had not bound very much and was badly cut up and rutted by wheels. Since then it has been tamped and rolled occasionally and is somewhat improved, although it still ruts. Possibly better results would have been obtained had a heavier roller been used. In another place, 99 sq. yds. were treated with this same oil, using 2.8 gals. to the sq. yd. The section used here was 6 inches deep in the center and 1 inches on the sides, but when travel was turned on it rutted somewhat and showed a tendency to cut through.

A heavy asphalt residuum oil known as Asphalt Macadam Binder No. 8, furnished by the Standard Oil Co., was used in treating 180 sq. yds., 1½ gals. of the binder being used to each sq. yd. of surface. The surface began to harden in 24 hours, and was quite hard in two or three days, being rolled occasionally. When travel was first turned on, in about nine days, it rutted slightly, but has since hardened so that it holds up travel and is now in good condition. In another place 37 sq. yds. were treated with the same mixture, 6 ins. deep in the center and 4 ins. on the sides, 2.40 gals. being used to the sq. yd. This section rutted slightly, as did the first section, where a thinner coat was used, but it soon hardened so that it would hold up travel and is now in good condition.

Fluxing oil, a heavy asphalt residuum oil, furnished by the Gulf Refining Co., was used in treating 208 sq. yds. of surface, using 1.63 gals. per sq. yd. The mixture began to harden in two or three hours, and was hard enough to hold up travel in 24 hours. It was rolled only for one day. Travel was turned on in three days, and has made no impression on the surface, nor has it been affected by freezing or thawing; it is still in good condition.

Asphaltoilene, a light oil, furnished by the Good Roads Improvement Co., was used on 170 sq. yds., using 1.94 gals. to the sq. yd. It has been rolled repeatedly with light rollers. Travel was turned on in about a week. The material has not hardened very much nor compacted, and is still very loose.

Asphalt and fluxing oil, in equal parts, was used on 163½ sq. yds., the materials being procured from the Gulf Refining Co., 2⅓ gals. of material to the sq. yd. being used. It was found that unless all the materials—oil, asphalt, and sand—were extremely hot (200° F.) they would not mix properly, and that the asphalt tended to settle and "ball up." In order to produce good results the heating had to be very carefully done. The mixture had to be turned from six to eight times. It hardened very quickly and was very hard in 24 hours. It held up travel well, without any indication of breaking up or rutting, and is still in good condition.

"A" asphalt one part, fluxing oil, three parts, was used in treating 187 sq. yds. of surface. This mixture was more easily handled than the one mentioned above, and hardened in about 24 hours; 2⅓ gals. were used to the sq. yd. Travel was turned on the road in 24 hours, and there has been as yet no indication of rutting or breaking up, and the surface is still in good condition.

A heavy asphalt residuum oil, furnished by the Indian Refining Co., was also used. This oil is somewhat lighter than the asphalt macadam binder No. 8, or the Gulf Refining Co.'s fluxing oil. With this material 71 sq. yds. of road were treated, using 2½ gals. of oil to the sq. yd. The mixture began to harden in a few hours and was quite hard in 24 hours. Travel was turned on in five days. It shows a slight indication of rutting, but has not rutted badly or broken up under travel. It is still in good condition, although it does not seem to be quite as hard as the sections that were built with the asphalt macadam binder No. 8, or where the Gulf Refining Co.'s fluxing oil was used, and is much softer than where asphalt was mixed with the oil.

A light asphalt residuum oil, furnished by the Indian Refining Co., was used to treat 172 sq. yds. of surface, using 3¼ gals. to the sq. yds. The oil mixed very readily with the sand, commenced to harden in about two days and was quite hard in four days. It has rutted somewhat, but there are no ruts over 1 in. or so in depth, and it has held up heavy teams.

Texas oil, furnished by the Texas Oil Co., was also used, 131½ sq. yds. being treated, using 2¾ gals. per sq. yd. This oil is quite light and runs readily out of the barrel, but apparently has good binding qualities. It hardened considerably in one day, and in three days was hard enough to hold up travel, with only slight ruts and no indication of breaking up. At present the road is in good condition, and it compares favorably with other sections of road, where heavier oil was used.

SAND AND OIL ROADS.

The sand and oil experiments were in continuation of some that the commission tried in 1905 in Eastham. Two sections of road were treated there, one section a macadam road, which was treated with an oil and sand mixture, and the other a section of sand road, which was oiled, the oil being heated and allowed to soak into the road, and then being thoroughly harrowed and the road shaped and rolled.

The oil which was used was like fluxing oil, a heavy residuum asphalt oil, which was claimed to contain 65 per cent of asphalt. The oil was heated to 180° or 200° F., and applied from a watering cart with a special sprinkling attachment.

After the oil had stood two or three days, sand was put upon it. The work was done late in the fall and was not satisfactory; in fact, it was considered a failure, and it was not until the next year that the oil began to appear upon the surface and to become compact under travel.

In 1907 this road was rolled with a steam roller and patched. While it ruts under travel, and is not in any sense as smooth as a macadam road, it has proved satisfactory in that it has held up travel and only rutted to a slight depth, and is still in reasonably good condition, after three years of wear.

The cost in 1905, when something over a mile of road, 16 ft. wide, was treated, was about $0.17 per sq. yd., using a little less than 1½ gals. of oil to the sq. yd. The road was treated a second time in 1906, using .7 gallon to the sq. yd., at a cost of $0.1084 per sq. yd. This made something over 2 gals. of oil to the sq. yd. of road. It has been patched somewhat during the last year.

During the hot weather the oil comes up to the surface, and the division engineer has estimated that some $400 will be necessary next year to fill ruts and depressions in the road and put it in good condition. The cost of this road up to the present time has been about $2,400 per mile.

It was the experience of the commission with this road that decided it to try the various experiments outlined above, to see if sand roads could not be built, using oil, asphalt or tar as a binder, without the use of stone. It is evident that if satisfactory roads, which will withstand ordinary travel, can be built with sand and these materials, the first cost of the same will be only about 25 per cent of the cost of a macadam road. The oiled roads will probably cost from $1,500 to $2,000 a mile, using a heavy residuum asphalt oil, which costs about $0.055 to $0.06 per gal., and using about 2 gals. to the sq. yd. Undoubtedly, after several years, such roads will have to be treated with a second coat of oil, and all ruts and depressions will have to be filled every year.

The commission has, during the past season, been building a State road of oil and sand in Harwich, Brewster and Orleans, where a section about three miles in length is being constructed. The method is, in general, the same as that used in Eastham. Up to the present time, while the oiled road seems to be much better than the sand road it has heretofore had many defects. It has been impossible to secure an even layer of oil and an even thickness of the oil and sand mixture throughout the width of the road. Undoubtedly this can be cured in some way. It is due to the fact that during construction the horses' feet make holes in the sand, and the subgrade is rutted deeply by the wheels of the carts. The oil, no matter how evenly it is spread, tends to settle into the depressions.

The defects, however, seem to be due to the methods of construction rather than to any inherent trouble with the materials used. It is possible, of course, although considerably more expensive, to mix all of the oil and sand upon the roadside, grade the section of road to be treated, and to then apply the oil and sand mixture in an even layer. If a mechanical mixer is used, the expense of this method will not be prohibitive.

In some places it may be possible to spread the oil in even layers from the roadside, where there is sufficient width to allow the cart to travel upon the shoulders. It may be possible to construct some special tank wagon with a wide enough axle to reach across the road and spread the oil from that, without rutting the road, shaping it behind the horses. If this method is used it will probably be best to put the oil on in a thin layer of ½ gal. to the sq. yd., and then cover it with about 1 in. of sand to each layer of oil, as the oil, in warm weather, tends to work up through the sand rather than down.

It is impossible at the present time to state which of the various materials used will prove the best. It does seem probable, however, that some one of these materials and mixtures will prove to be satisfactory, and can be used for the purpose of producing not only a dustless road but one that will withstand automobile travel, and can also be used in combination with sand or gravel to produce a road which will withstand any ordinary travel, be dustless and not cost more than 25 per cent to 30 per cent of the cost of a macadam road.

Even if such roads have to be treated every year, at an expense of from $0.05 to $0.0[illegible] per sq. yd., they would probably prove to be cheaper than macadam roads, especially taking into account the first cost of construction, and the fact that a binder of some character has to be used upon macadam roads as well, in order to prevent their being destroyed by automobiles.

ROADS TREATED WITH TARVIA IN 1907.

There were several stretches of road treated with tarvia A in 1907, this being a refined tar product procured from the Barrett Manufacturing Co. These were at Wayland, Weston, Lynn and Westwood, and a section in Bourne. The results differed in the various places.

In Weston the roads were unsatisfactory, the refined tar on the surface disappearing over 50 per cent of the surface during the season of 1907. In Wayland, Lynn and Westwood the tarvia remained upon the surface, and in fairly satisfactory condition, during the season of 1907. In 1908 a number of holes appeared from time to time where the tarvia had worn out or disappeared. When such bad places are patched immediately with tarvia or a mixture of tarvia and pitch, the road may be kept in good condition until another general treatment is needed. The cost of the patching that had to be done in 1908 varied from 1 cent to 2 cents per sq. yd. of the entire surface of the road. As with the oil treatments, the best results were obtained when the material was placed upon clean, well-compacted stone, and where there were no dust pockets or loose stones underneath.

In Wayland and Bourne it seems at the present time that the roads should go through another season with nothing but patching, and without any retreatment of the whole surface. In Lynn and Westwood the tarvia has worn off so that it is probable that the road will have to be resurfaced with a light surfacing of refined tar, and pea stone or sharp sand added, to reproduce a wearing surface.

Where these roads were not tarviated for the entire width there has been a tendency for the tarvia on the shoulders or edges to crack off, and for the road to begin to ravel there. Experience seems to indicate that practically the entire width of the roadway should be treated, though this will cost more money.

The original cost of the tarvia A work done in 1907, including rolling and the top-dressing, was from 10 cts. to 12 cts. per sq. yd., but it is expected that retreatments will cost much less.

In concluding the report on its experimental work the commission advances the following general considerations and tentative conclusions:

So far as the experience of the commission is concerned, it seems evident at the present time that in order to produce good results by the use of oil, and to accomplish anything more than the temporary laying of dust, it is necessary to use oils which have an asphaltic base,—the larger the percentage of asphalt, speaking generally, the better the results.

The oils should actually contain an asphaltic base, and not be merely oils or residuums which are claimed to contain such a base. The lighter oils with an asphaltic base, as has been stated elsewhere, will maintain a road that is in proper condition, to wit, with no dust pockets or loose stone, using about ½ gal. to the sq. yd. of surface treated, and covering with pea stone, sharp sand or gravel, for one year, without serious deterioration.

It appears now that the heavier oils, which must be heated in order to be applied, will last for a longer time without being re-treated. The indications are also that these heavier oils, possibly enriched with the right quantity of asphalt, will make a permanent roadbed when mixed in proper proportions with sand, and will very likely prove effective in resurfacing old macadam roads if a layer is put on 2 ins. thick in the center and 1 in. on the sides, compacted and rolled. Undoubtedly such roads will require additional coats of oil, sand or gravel from time to time. The experience of the commission in regard to these materials is the same as is indicated in reports on oiled roads in California and in reports of the Agricultural Department in Washington.

The experiments of the commission and the analyses of its chemist are in accord with the experience in the use of various tar products both in this country and abroad, so far as can be learned. Experience everywhere shows that different so-called tars vary very much in quality, even when they are procured from the same plant.

Generally speaking, when a permanent binder is desired good results are obtained only when a refined tar is used, or a tar and pitch mixture which makes a material similar to refined tar, and when the material used has the proper specific gravity and contains the proper ingredients. Unrefined tars vary so much in quality and character, and [illegible] from time to time, that it is almost impossible to be sure of obtaining good results.

It may be stated, generally, from the experiments of the commission and from experience elsewhere, that it is essential that the tars used should not have been overheated and must not contain too much free carbon; they must have been refined, and the ammoniacal liquor, water and volatile products must have been eliminated, otherwise one can be sure that the results will not be satisfactory. The reports of experts seem to indicate that the best quality of tar is procured from plants where the tar is not overheated, and that such plants are usually where coke or coal gas tar is made, but that where water-gas tar is manufactured or water gas tar and coal-gas tar are both manufactured, the residuum tar products are likely to be poor and to contain too much free carbon.

The commission does not feel justified at this time in making any more than a few general statements as to its experiments, because the roads have not been constructed long enough to demonstrate how the various materials will wear or how they may be affected by frost.

Experience has shown, also, that if ordinary tar is heated for two hours or more a very large proportion of the lighter products will be expelled, and the quality will be much improved. Of course, if refined tar is bought in the first instance this is not necessary.

It also seems probable that in many localities, if ordinary gas-house tar is used (which can often be obtained at a very low price at the local plant), and it is heated for two or three hours and thereby somewhat refined, that it can be mixed with a small quantity of pitch, asphalt or some other material (the nature of which can be ascertained by analyses and experiments by a competent chemist), and that good results can be obtained by using it in the proper manner upon the roads.

It also seems probable that tar can be mixed with hot sand, and put upon an old macadam road in a 2-in. section, thereby producing a sand-tar top which will withstand travel for a considerable time, when the road is in such a locality that its slipperiness will not be objectionable.

Steam Road Roller Maintenance.

The Massachusetts Highway Commission had under its control during 1908 18 steam road rollers. These rollers were used 1,126¾ days on town work, in 32 different towns. They were also used 557½ days on state highway repair work, on 65 different roads; 290 days by towns contracting for the building of state roads, including the small town roads; 162 days by private contractors on state highway contracts, and one roller was used eight days at the State Farm at Bridgewater. The total number of days' work during the year was 2,144—an average of 119 days for each roller. The total cost of such maintenance for the year was $2,046. Of this amount $1,000 was paid for practically rebuilding one of the rollers which had been in active use since 1896, and $1,046 was expended for the ordinary repairs. Including the expense of supervision and inspection of the rollers, the average cost of such ordinary repairs during 1908 was 90.8 cts. per day for each roller in use. A comparison of the above figures with those of the years 1906 and 1907 is given below:

	1906	1907	1908
Number of rollers	16	16	18
Total days worked	[illegible]	1,808	2,144
Av. days per roller	[illegible]	[illegible]	119
Av. cost of ordinary repairs per roller per day	$0.98½	$0.99¼	$0.90 4/5

Tables for Use in Road and Street Work.

Areas of Waterways for Culverts.—In determining the proper area for water ways in culverts, Talbot's formula

$$A = C\sqrt[4]{D^3}$$

has been used extensively by railways. In this formula A is the area of waterway in sq. ft., C is a coefficient depending upon the nature of the watershed and D is the drainage area in acres. The accompanying tabulation has been figured out from the above formula the value of the coefficient C being assumed to be as follows: Very mountainous territory C = 1; mountainous, C = ⅔; very hilly, C = ½; hilly, C = ⅓; rolling, C = ¼; gently rolling, C = ⅕; prairie, C = ⅙. In the table opposite the given number of acres in the drainage area and under the proper classification of watershed will be found the required area of waterway in sq. ft.

Drainage Area—Acres	Very Mountainous	Mountainous	Very Hilly	Hilly	Rolling	Gently Rolling	Prairie
5	3.3	2.2	1.7	1.1	0.8	0.6	0.5
10	5.6	3.7	2.8	1.9	1.4	1.1	0.9
15	7.6	5.1	3.8	2.5	1.9	1.5	1.3
20	9.5	6.3	4.7	3.2	2.4	1.9	1.6
25	11.2	7.5	5.6	3.7	2.8	2.2	1.9
30	12.8	8.5	6.4	4.3	3.2	2.6	2.1
40	15.9	10.6	8.0	5.3	4.0	3.2	2.6
50	18.8	12.5	9.4	6.3	4.7	3.8	3.1
60	21.6	14.4	10.8	7.2	5.4	4.3	3.6
80	26.8	17.8	13.4	8.9	6.7	5.4	4.5
100	31.6	21.1	15.8	10.5	7.9	6.3	5.3
120	36.3	24.2	18.1	12.1	9.1	7.3	6.0
140	40.7	27.1	20.4	13.6	10.2	8.2	6.8
160	45.0	30.0	22.5	15.0	11.2	9.0	7.5
180	49.1	32.8	24.6	16.4	12.3	9.8	8.2
200	53.2	35.6	26.6	17.7	13.3	10.6	8.9
220	57.1	38.0	28.6	19.0	14.3	11.4	9.5
240	61.0	40.8	30.5	20.3	15.2	12.2	10.2
260	64.8	43.2	32.4	21.6	16.2	13.0	10.8
280	68.5	45.6	34.2	22.8	17.1	13.7	11.4
300	72.1	48.1	36.0	24.0	18.0	14.4	12.0
340	79.2	52.8	39.6	26.4	19.8	15.8	13.2
360	82.6	55.2	41.3	27.6	20.6	16.5	13.6
400	89.4	59.6	44.7	29.8	22.3	17.9	14.9
450	97.7	65.2	48.9	32.6	24.4	19.5	16.3
500	105.7	70.4	52.9	35.2	26.4	21.1	17.6
550	113.5	75.6	56.7	37.8	28.4	22.7	18.9
600	121.2	80.8	60.6	40.4	30.3	24.2	20.2
650	128.7	85.8	64.3	42.9	32.2	25.7	21.4
700	136.1	90.8	68.0	45.4	34.0	27.2	22.7
750	143.3	95.4	71.6	47.7	35.8	28.7	23.9
800	150.4	100.2	75.2	50.1	37.6	30.1	25.1
850	157.4	105.0	78.7	52.5	39.4	31.5	26.2
900	164.3	109.6	82.1	54.8	41.1	32.9	27.4
950	171.1	114.0	85.5	57.0	42.8	34.2	28.5
1000	177.8	118.4	88.9	59.2	44.4	35.6	29.6
1100	196.0	127.4	95.5	63.7	47.8	36.2	31.8
1200	203.9	135.8	101.9	68.0	51.0	40.8	34.0

Ordinates for Crowning Street Pavement.—The accompanying table has been found very convenient in setting grades for crown of streets, and for testing and cutting templates for circular crowned streets. In using the table points are taken from the center line toward gutter in fractional part of half of street width. To obtain rod reading at point sought the decimal in table is added to grade rod reading. The following example is given to show the method of using the table in setting grades across the street. Rod at center of street crown = 4.38; gutter 8 in. below crown; width between curbs = 40 ft.; desired rod readings at ⅕, ⅖, ⅗, ⅘ and gutter. Half street width = 20 ft. Set pegs 4, 8, 12, 16 ft., from center line and at gutter. Then from .03 = 4.41; 8 ft. = 4.38 plus .11 = 4.49; 12 ft. table, rod at first or 4 ft. peg = 4.38 plus = 4.38 plus .24 = 4.62; 16 ft. = 4.38 plus .67 = 4.81. At gutter = 4.38 plus .67 = 5.05. The table has been used by the City Engineers' Department of Springfield, Mo., and we are indebted to Mr. E. M. Essex of that department for the information given above.

ORDINATES FOR CROWNING PAVEMENT.

Dist. From C. L. Fraction of $\frac{\text{Width}}{2}$			Below Grade when Gutter Depth is—			
			6"=0.5'	8"=0.666'	10"=8.833'	12"=1.000'
Center			.000	.000	.000'	.000'
1-20			.001	.002	.002	.003
2-20	1-10		.005	.007	.008	.010
3-20			.011	.015	.019	.023
4-20	2-10	1-5	.020	.027	.033	.04
5-20		1-4	.031	.042	.052	.063
6-20	3-10		.045	.060	.085	.09
7-20			.061	.082	.102	.123
8-20	4-10	2-5	.080	.106	.133	.16
9-20			.101	.135	.168	.203
10-20	5-10	1-2	.125	.167	.208	.25
11-20			.151	.201	.251	.303
12-20	6-10	3-5	.180	.240	.299	.36
13-20			.211	.281	.351	.423
14-20	7-10		.245	.327	.407	.49
15-20		3-4	.281	.375	.467	.563
16-20	8-10	4-5	.320	.426	.531	.64
17-20			.361	.481	.600	.723
18-20			.405	.540	.672	.81
19-20			.451	.601	.749	.903
Gutter			.500	.666	.833	1.000

Weight of Drain Tile.—Porous or farm tile laid 3 or 4 ft. deep on one or both sides of the roadway is the best method of securing underdrainage for highways. Tile may be had from 3 to 30 ins. in diameter. The smaller sizes are usually 1 ft. long and the larger sizes are 2 or 2½ ft. long. The accompanying table shows the weight per foot and the average carload for various sizes of tile:

	Weight Per Foot. Lbs.	—Aver. Carload.— No Pieces.	Rods.
4-in. tile	6	6,500	390
5-in. tile	8	5,000	300
6-in. tile	11	4,000	240
7-in. tile	14	3,000	180
8-in. tile	18	1,200	144
10-in. tile	25	800	96
12-in. tile	33	500	60
14-in. tile	43	400	48
15-in. tile	50	300	36
16-in. tile	53	250	30
18-in. tile	70	200	24
20-in. tile	83	166	20
22-in. tile	100	160	19
24-in. tile	112	150	18
30-in. tile	192	65	10

Cu. Yds. of Broken Stone Per Mile.—The accompanying table shows the number of cubic yards of broken stone per mile required to make a given loose depth for various widths of road:

	Depth Loose Mater'l. Ins.	—Width of Stone Bed— 8 ft. Cu. yds.	9 ft. Cu. yds.	10ft. Cu. yds.	13ft. Cu. yds.	14ft. Cu. yds.	16ft. Cu. yds.
Screenings	1½	196	220	245	293	342	391
	3	391	440	490	586	684	782
	4	521	587	652	782	913	1043
	5	652	734	815	978	1141	1304
	6	783	880	978	1173	1369	1565

Loose stone will reduce about ¾ of its depth after being thoroughly rolled, this reduction, however, depending somewhat on the condition of the subsoil. A fair average weight for crushed limestone is 2,500 lbs. per cu. yd.; granites and quartzites average 2,600 lbs. per cu. yd. and trap rocks about 2,700 lbs. per cu. yd. To convert the above table to tons per mile, ¼ should be added to the figures to obtain the number of tons per mile required for a limestone road of given depth and width, .3 for tons of granite or quartzite and 7/20 for tons of trap rock.

Iron Pipe Data.—Iron pipe is used frequently by railroad companies in culvert work, and the following table gives some data on the sizes commonly used:

Size Opening. Inches.	Average Opening. Sq. Ft.	Weight Per Ft. Lbs.	Thickness. Inches.
18	1.76	167	⅞
24	3.14	250	1
30	4.91	350	1⅛
36	7.07	475	1⅜
48	12.57	775	1½
60	19.63	1330	2

Notes on Road, Maintenance and Repair.

Maintenance is as important as construction. Roads deteriorate very rapidly if neglected. Rain, frost, freshet, drought, wagon traffic, the steel shod feet of horses, narrow tires, combine powerful forces to flatten, rut and destroy roads.

Roads should be maintained by not allowing them to get out of repair. Neglect to keep roads in repair, failure to repair them when repair is first needed, adds very much to the cost of roads. A good road which is not kept in repair very quickly becomes a bad road, and the object of the original expenditure is thus lost. To allow roads to degenerate for want of repair means an immense waste of labor, material and money, which has to be made up in their reconstruction. Whenever good roads are built, arrangements should be made for a careful attention to their repair.

Public highways should be kept in repair by a system similar to that adopted by railways. Where a council, as is commonly the case, provides materials, gravel, tile, etc., for road maintenance, out of the general funds, one sectionman with horse and cart, and help when required, can keep in repair ten miles of gravel or stone road at a cost not exceeding the statute labor along the road, commuted at one dollar a day.

A road as commonly built for country traffic should receive as much attention the first year after construction as it would require in the following two years. This is especially necessary if gravel or stone is placed loosely on the road and left for traffic to consolidate.

A large part of the repair of roads is necessitated by defective construction. A poorly made road will wear out much more rapidly than one which has been well built. To construct roads properly may be greater in first cost, but this is compensated by the reduction in the outlay for maintenance in addition to the benefits of better roads.

Roads should be kept smooth. Smooth roads shed water more readily than do rough roads. It is not the even roll of a wheel over a smooth road that causes injury. It is the jarring action of wheels dropping from loose stones, from protruding stones, or sinking into holes and ruts.

When a road is newly built, drive a wagon up and down a number of times and make a track where vehicles are wanted to go. This is especially necessary if the gravel or stone is not rolled or if there is a tendency to drive on the earth shoulders. Teams are very like sheep—they follow the leader.

Hollows and pitch holes should not be allowed to form at the ends of culverts and bridges projecting above the surface of the road. These pitch holes form because every vehicle crossing the bridge drops down with a heavy jolt. Shallow at first, the deeper the holes become the more rapidly they increase in size and depth, because the pounding action of the wheels increases with the depth. Water collects and remains in these holes, and assists the wearing action of the wheels.

Wherever there is a roughness of any kind, a projecting or loose stone, a soft or hollow spot in the road, there is the same pounding action of the wheels assisted by the collecting of pools of water, which lie in every depression.

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*From the report for 1909 of A. W. Campbell, Deputy Minister of Public Works for the Province of Ontario, Canada.

Water-works and Sewer Section

Note: This section is devoted to methods and costs of constructing sewers and water-works. It will cover the construction work for all details of water supply and sewerage, including sewage purification and water filtration.

Culvert and Sewer Design, With Especial Reference to Reinforced Concrete.*

BY ERNEST McCULLOUGH†

Centuries ago men commenced to build masonry tunnels to carry water to their cities. Later they commenced to build masonry tunnels to rid their cities of filth. These water conduits and sewers were built in accordance with rules evolved through years and generations of experience, and today we are following the rules given by men who built sewers in Rome and Babylon. No difference can be found, because masonry does not change, and until reinforced concrete came in the only force considered as acting on sewers was pressure in the form of compression.

Today the problem comes to me as engineer for a firm selling reinforcing material the request from our salesmen to give them some plans for sewers for some city engineer, said sewers "to be as strong as a one-ring, two-ring, or three-ring brick sewer," for which plans have been already prepared. You will see that two problems come in at this point. One is to determine how strong the brick sewer is, and the other to design a reinforced concrete sewer strong enough to do the work, and yet requiring so little reinforcement that we can sell in competition with other manufacturers, every one of whom, we may be sure, has engineers wrestling with the same problem.

Literature on the subject of sewer design is scanty. So far, it has been simply one man copying from another, with now and then a bold man trying experiments in order to spread a small sewer appropriation over a very large area. Occasionally these experiments are successful when conditions are right, and the long list of failures following in the track as a result tends to discourage men straying from time-tried and accepted standards.

On the subject of brick sewers we are told that one ring of brick (1½ ins.) is generally sufficient for sewers up to 3 ft. in diameter, and that two rings (9 ins.) will be sufficient for sewers up to about 6 or 8 ft. in diameter. Beyond that it is a matter of following someone else, although a number of engineers say that after a diameter of 8 ft. is reached there should be an additional ring of brick for each nine ins. increase in diameter.

Baldwin Latham in 1873 gave the following formula by which to determine the thickness of sewer walls, circular sewers or sewers having a semi circular top:

Let t = thickness of brickwork in feet

d = depth of excavation in feet

r = external radius of sewer in feet

then

$$\frac{dr}{100} = t$$

In using this rule it is necessary to first assume some thickness and add twice the assumed thickness to the internal diameter, for the radius he gives is the external radius.

He states that the number of rings of brick (4½ ins. per ring) is determined by dividing the thickness found by the formula by the thickness of a ring of brick and throwing the fraction of a ring thus found into the wall, so that actually the thickness found by the formula will be likely to be slightly increased, because the bricks have a definite width.

Mr. Latham states that he derived this formula from experiments made to determine the crushing strength of brick work, the brick having been found strong enough to carry a column of earth 100 ft. high. It will be noticed that his rule will give sewer walls of a thickness corresponding to the depth of the fill and varying directly with this depth. We know well that at some point the pressure stops increasing directly as the depth, so his rule is of no great value except as a starting point for calculations.

Engineers who disliked fixing the thickness of sewer walls by mere rule of thumb have used the foregoing formula as a starter on sewers designed for shallow depths and used their judgment when they got deeper. Other engineers have used the following rule for depths of arch rings devised by Rankine:

$$D = C\sqrt{r}$$

in which

r = internal radius in feet.

D = depth of arching (thickness at top).

C = a constant = 0.2 for concrete.

= 0.3 for block stone.

= 0.4 for brick.

= 0.45 for rubble.

That this formula has had a great deal to do with the present methods of brick sewer construction may be surmised when we calculate the number of rings of brick required for sewers of different diameters. For example: 3 ft., 1 ring; 4 ft., 2 rings; 6 ft., 2 rings; 8 ft., 3 rings; 10 ft., 3 rings; 12 ft., 3 rings; 14 ft., 4 rings.

Prof. Rankine says the horizontal thrust in an arch nearly equals the weight supported between the crown and that part of the soffit whose inclination is 45°.

In a straight arch of brick with radiating joints

$$D = 0.45\sqrt{S + \frac{S}{12}}$$

where D = thickness of arch ring at top

S = span.

An arch of 40° is the flattest than can be constructed with safety when depth at crown (thickness) = $C\sqrt{r}$

In this connection there might be given some formulas used frequently by older engineers for arches, but we are today learning so much about the elastic theory of the arch that the empirical rules of former generations must be ignored. Engineers of an earlier generation, remember, had non-cohesive masonry, whereas we have masonry of a superior kind that can handle any sort of stress. We engineers of this generation have bending moments to consider, and are not compelled to put into the form of empirical rules, in a mnemonic form, the results of accumulated experience in arch building. We can deal with the known existing forces and design accordingly.

It was with some such idea in view that my studies commenced in order that we might, if possible, design reinforced concrete sewers rationally and not be dependent upon a comparison with brick sewers that might, or might not be really stronger than necessarily called for.

Before dipping into this, however, it may be of some historical interest to tell what was found regarding concrete sewers. Baldwin Latham in 1873 describes sewers of a composite nature built of brick and concrete. He also tells of sewers made of concrete blocks alone, and of sewers partly monolithic and partly of blocks. He describes these sewers as if they were matters of common knowledge at the time he writes, yet within the last three or four years the United States Patent Office has granted patents for just such structures. He also tells about examining concrete sewers that had been in use then for over 20 years, and which were in perfect condition. However, he also sounds a warning as to the proper selection of cement. This carries us back to the early '50s in the last century. All that Mr. Latham says sounds very much like the enthusiastic recommendation of a concrete crank of today, so we can hardly say we know more today about the possible advantages of concrete over brick than were known 60 years ago.

Baumeister has little to say about the thickness of brick sewers and gives a formula for thickness of sewer walls that depends entirely upon internal pressure. For concrete sewers, however, he gives some thicknesses in general use in Europe for plain concrete, these thicknesses being the result of many years' experience in building such sewers. They are, averages:

Diam. 8 ins., thickness, 1.6 to 2.0 ins.
Diam., 18 ins., thickness, 2.4 to 3.2 ins.
Diam., 24 ins., thickness, 3.5 to 4.7 ins.
Diam., 31 ins., thickness, 4.7 to 5.9 ins.
Diam., 39 ins., thickness, 5.9 to 7.1 ins.
Diam., 47 ins., thickness, 6.7 to 7.9 ins.
Diam., 55 ins., thickness, 7.9 to 9.1 ins.

A large number of examples show thickness to be from 1-6 to 1-7 diameter and in drains up to 20 ins. diameter up to 1-5 *d*. The Paris sewers, from 5 to 8 ft. diameter, had a thickness of about ⅛ the diameter.

Messrs. Dyckerhoff & Widman (Baumeister) give the following dimensions for pipes in use, which they believe are perfectly dimensioned:

Diam., 8 ins.; thickness 1.7 ins.
Diam., 10 ins., thickness 1.8 ins.
Diam., 12 ins., thickness 2.1 ins.
Diam., 16 ins., thickness 2.8 ins.
Diam., 20 ins., thickness 3.2 ins.
Diam., 24 ins., thickness 4.7 ins.
Diam., 31 ins., thickness 5.9 ins.
Diam., 39 ins., thickness 7.3 ins.

For sewers under 2 ft. in diameter the material should be a cement mortar, but for larger sizes may be a concrete containing stone or gravel not exceeding ½ in. in any dimension.

In California about 15 years ago I built some concrete sewers in which the thickness was arbitrarily fixed as follows. The minimum thickness was 5 ins. For sewers having a diameter exceeding 4 ft. the thickness in inches was equal to the diameter in feet plus one. This then gave us a 7 in. wall for a 6 ft. sewer. A brick sewer this size would be 9 ins. thick.

For reinforced concrete sewers a rule was given me about that time by an engineer whom I have forgotten, which was that the thickness of the sewer in inches could be equal to the diameter in feet minus half an inch. The reinforcement to consist of bars or rods having an area equal to 1 per cent of the area of the wall of the sewer in the circumference and with longitudinal rods or bars equal in area to one-third of 1 per cent of the ring. Sewers have been built in accordance with this rule in many cities. I have a hazy impression that this rule was published in some technical paper 15 or 16 years ago, and that I got it thus. In those days we copied rules for reinforced concrete in our notebooks, without investigating their source.

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*A paper read before the Illinois Society of Engineers and Surveyors at the annual meeting, Chicago, Ill., January 27-29, 1909.

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Earthernware pipes have been used for several centuries for sewers and the thickness of these pipes has been developed by experience. The thickness of an ordinary standard pipe is generally about one-sixteenth its diameter. They were seldom larger than 30 ins. until a few years ago, and experiments made in England showed that in the early '60s of the last century the manufacturers generally were supplying pipes that had an ultimate strength of from 600 lbs. to 900 lbs. per sq. in. in tension and from 4,500 to 7,000 lbs. per sq. in. in compression, the pipes breaking under internal pressures of from 80 to 100 lbs. per sq. in.

A few years ago manufacturers commenced sending out what are known as "double strength" pipes, principally in the larger sizes. In 1890 Prof. Howe made experiments on sewer pipes and found that they generally broke under a hydrostatic pressure of 100 lbs. per sq. in. and that the tensile strength thus shown was about 600 lbs. per sq. in. The largest pipe tested was a 24-in. pipe and it was also found that the average pipe supplied by the manufacturers was capable of carrying a load of 2,000 lbs. per lin. ft. when embedded in sand. Experiments made later by manufacturers on "double strength" pipe show that this heavier pipe will stand a hydrostatic pressure of practically 200 lbs. per sq. in.

All this investigation was necessary in order to get back to some idea of what amount of pressure we should figure on to design sewers of reinforced concrete, and yet if one looks into the data he will find that pipes are often placed in the ground at depths that are too great, if we accept the published rules for earth pressure, to-wit: that the pressure is equal to a column of earth the width of the buried structure and in height equal to the depth of excavation to the top of the structure. You have all read the statements that for the tops of culverts you must count on all the earth above the culvert as being carried by it. The pressure on the sides of the culverts is equal to one-third the vertical load, and the bottom reaction is equal to the top pressure. Therefore, make the bottom of your culvert, if box shaped, the thickness of the top. In spite of the fact that various speculations of theorists have been published, and facts have been given to sustain their statements, the greater number of men today who design culverts are using the foregoing rules and using, therefore, an excessive amount of steel, and, when this steel is taken into account, an excessive amount of concrete. Railroads for years used culverts of wood with tops only 6 ins. thick. These culverts did not give way until the wood rotted, so the 6-in. tops were evidently strong enough for all practical purposes.

No particular pains were taken with the old wooden railroad culverts to keep the sides from caving in, and these sides consisted of square timbers laid one on top of the other. Six inches square for three timbers high, 8 ins. square for five timbers high and 10 ins. square for six timbers high. Sometimes they were fastened together by drift bolts, but very often they were not. There was an idea that the pressure would hold them in place. I helped put some in myself a number of years ago in the West. The tops consisted of 6-in. pieces and every eighth piece was notched down on to the sides to help hold the sides. These culverts were often built without any bottom. Standard plans sent from the office called for cross sills of 4x8 from 4 to 8 ft. on centers simply put in as joists to carry a floor 2 ins. thick. This floor was supposed to be there to prevent the sides from squeezing in, as well as to resist scouring action when the water ran freely. The floor and cross sills were often omitted. If the upward reaction was great enough to demand a bottom as thick as the top, then why did not the culverts without floors sink into the earth, and why did not the floors break when they were put in?

A careful search was made for all data bearing on the subject and the best that can be offered may be found in a paper read by Mr. Frank A. Barbour, C. E., before the Boston Society of Civil Engineers and published in the "Journal of the Association of Engineering Societies," Vol. XIX, page 193. (This was in the year 1897.) You are referred to the volume mentioned for the full discussion, and I will give here only the conclusions.

The experiments of Mr. Barbour were undertaken for the purpose of preparing specifications for vitrified sewer pipe. So many failures were occurring that it was felt the purchaser should not leave it all to the manufacturer, but should be able to have pipes furnished in accordance with specifications to some standard. He tested many pipes and then devised the following formula for thickness, based on a tensile strength of 900 lbs. per sq. in. for clay and a compressive strength of 6,500 lbs. per sq. in., both values ultimate.

p = pressure in lbs. per linear foot.
t = thickness in inches.
d = diameter in inches.
c = a constant = 33,000.

then

$$p = c\frac{t^{1.65}}{d}$$

$$t = 1.65\sqrt{\frac{pd}{c}}$$

The best specifications today require that vitrified ironstone sewer pipe shall be able to stand a crushing load of 3,000 lbs. per lin. ft. on pipe under 12 ins. in diameter and 4,500 lbs. per lin. ft. for pipes exceeding 12 ins. in diameter.

Having determined the pressure the pipes will stand, it was necessary to learn how much pressure they might have to stand, and also when to require standard and when to require "double thick" pipes. For this purpose a trench was dug and a platform covering the bottom was attached to plungers in water-filled cylinders, so that the pressure could be conveyed to pressure gages when the platform was loaded. Pains were taken to reproduce as much as possible the conditions existing on ordinary jobs. Sometimes the trench was sheeted and sometimes it was not. Sometimes the sheeting was as smooth as possible, and at other times it had cleats nailed to it to study the effect of roughness on the settling of the fill. While this series of experiments give us all the data we have on the subject of earth pressures in trenches and are insufficient, perhaps, until verified by other experimenters, still the data obtained seem to accord very well with known facts.

Mr. Barbour states as a result of the experiments, in which many different materials were used, that the pressure of earth in a trench is a function of the cohesion of the material, rather than of friction on the sides of the trench or of the width of the trench. He gave a diagram showing all the results plotted, and I plotted a curve somewhat below the average, in order to give results leaning towards a good factor of safety, and from that curve obtained the following equation for depths of fill from 3 ft. to 10 ft., after which the percentage of weight is practically a constant:

Let p = pressure in lbs. per sq. ft.
w = weight in lbs. per cu. ft. of the filled material.
d = depth in feet of fill in trench.

For a 6-in. fill the pressure is 89 per cent of the weight. For a 1-ft. fill the pressure is 79 per cent of the weight. For a 2-ft. fill the pressure is 67 per cent of the weight. For other fills to 10 ft.:

$$p = \frac{wd}{100}\left[100 - 10\sqrt{4d} + (10 - d)\right]$$

The expression within the parentheses gives the ratio of lateral pressure to weight, and this becomes a constant at a depth of about 10 ft. and is equal to 37 per cent.

On the assumptions taken from the experiments cited the percentage of weight of filling transmitted to a buried structure will be the difference between unity and the tangent of the angle of repose of the material in the trench after reaching a depth of 10 ft.

When the banks of the trench were sloped at a ¼ to 1 slope and the trench filled, the ratio became a constant at about 52 per cent at a depth of 4 ft., the line then being horizontal. This would lend some color to the theory that buried structures in embankments would carry all the fill over them for any depth.

Ketchum, in his work, "Walls, Bins and Grain Elevators," gives the following table of the angles of repose for materials used for filling:

Earth, loam	30° to 40°
Sand, dry	25° to 35°
Sand, moist	30° to 45°
Sand, wet	15° to 30°
Clay	25° to 45°
Gravel	30° to 40°
Cinders	25° to 40°
Coke	30° to 45°

In addition to this earth pressure, we have to consider the effect of moving loads over the trench, such as wagons, street cars, road rollers, etc. These loads can be taken as concentrated on some definite area on the middle of the trench on top and spreading out therefrom in the form of a pyramid, the sides of which are inclined at an angle of 60°. After the effect of the live load has penetrated to a depth of 10 ft., however, its effect can merely be that of so much additional filling to that point. Thereafter the ratio of pressure transmitted vertically will be 37 per cent of the amount over the trench at a depth of 10 ft. By the time the effect of the live load has penerated 10 ft. the base of the pyramid will be considerably beyond the sides of the trench. Folwell says that the effect of the live loads is very small after the depth of the trench is twice the width. By depth is meant the depth to the top of the buried structure, and it is meant in this way throughout in this article. The width is the extreme width.

The side pressures in nearly all cases are comparatively insignificant, provided the trench has been well braced during the construction of the sewer, or if the work of putting in the sewer was rushed and the trenches left open for a short time only. We have, of course, to consider the nature of the material, but particular reference is here made to ordinary tough earth.

The depth to which we can safely excavate in any material depends upon the cohesive power of that material. When the cohesive power is lost the bank caves in, by slices usually. A crack appears on the surface a small distance away from the edge of the excavation, which goes down vertically and, practically, parallel with the side of the cut until it meets a crack that started in the side of the trench some distance down, running off at an angle, the angle practically of internal friction in the material. The material slips in on this angle instead of toppling forward. The surface at the bottom of the slide is really curved instead of straight, and if we are only sensible enough to appreciate the work done by investigators, we can calculate the size of the wedge of earth and know just where to put braces. I would recommend to all engineers a careful study of a paper by Prof. Ketchum published in Vol. LX of the "Proceedings of the American Society of Civil Engineers" (1908) and reprinted in some of the leading technical papers. ENGINEERING-CONTRACTING, Chicago, reprinted it August 26, 1908.

The only pressure that can come against the side of the buried structure will be that due to the small wedge-shaped end of one of the slices of earth that might slide in when the cohesive power of the material is lost. This pressure will not be fully exerted if the trench is well braced, or if it is well tamped when refilled.

For a circular conduit this side pressure is of little importance, for if it is designed as an elastic ring with reinforcement the side pressure is not counted upon. If the top alone is arched, then the pressure is carried into the sides formed to act as abutments.

For a square box culvert, however, the pressure at the middle height will be $p = 30d$, in which d is the depth in feet to that point and p is the pressure per sq. ft. The total pressure on a vertical strip 1 ft. wide is evidently $p \times h$, where h = total height. The side is a restrained slab and the bending moment is

$$M = \frac{p\,h^2}{7.8}$$

at a point about seven-twelfths of the height above the bottom.

After calculating the thickness of the side in this manner, determine its thickness if required to act as a column carrying the reaction. Then having found the thickness, the necessary amount of steel can be calculated and placed near the inside face. It will be found, usually, that the thickness required to take care of the load will be greater than that due to pressure.

It is usual to fillet the corners of box culverts, and at the bottom this fillet can extend at an angle sufficient to increase the base of the side wall to take care of the reaction. Then between may be placed a slab, reinforced or not, to protect against undermining.

Pressures being a function of the cohesion in the material, it follows that loose, granular material will have a much greater effect on a buried structure than will more solid material, and when the structure is in a fluid of course the pressure will be everywhere equal.

For the development of the following formulas reference is made to Bulletin 22, University of Illinois Experiment Station, and to page 99, Vol. 4 of the Transactions of the Association of Civil Engineers of Cornell University.

With a concentrated load at the crown of an elastic ring, the expression for bending moment at the end of the vertical diameter is $M = 0.318\ Pr$,

in which P = concentrated load,

r = internal radius plus half the thickness.

Assuming the length of the pipe as unity the resisting moment is

$$M_r = \frac{st^2}{6}$$

where s = the unit stress in the remotest fiber,

t = thickness.

When the thickness is small compared with the diameter, this formula is approximately correct. For egg shaped pipes r is the horizontal diameter.

Equating the two moments gives

$$\frac{s\,t^2}{6} = 0.318\ P\ r$$

$$s = \frac{6(0.318Pr)}{t^2}$$

When P is in pounds per linear foot

$$s = \frac{0.159Pr}{t^2}$$

$$t = \sqrt{\frac{0.159Pr}{s}}$$

Professor Talbot gives $M = 0.159\ Pd$ in which d = mean diameter in inches.

M = inch pounds per inch when the length is taken in inches and is inch pounds per linear foot when the length is 1 ft. Considering a ring 1 in. long P is in pounds per square inch and when we take a pipe 1 ft. long P is in pounds per 1 in. wide by 1 ft. long. Elementary perhaps but the failure to explain this in several books has led to some strange ideas.

The greatest bending moment for a concentrated loading is at the top and bottom of the ring, the moment being $= 0.16\,Pd$, while at the sides it is $= -0.09\,Pd$. The steel in the shell should be near the inside on the top and bottom and near the outside on the sides.

For a distributed load across the diameter of the pipe let

d = diameter of pipe in inches,

p = pressure per unit area as above explained,

M = bending moment in unit length of pipe.

M at bottom and top $= \frac{pd^2}{16}$ with steel towards the inside of the shell and the same bending moment at the sides at the greatest horizontal diameter, with the steel toward the outside of the shell.

In making this calculation it is enough to bear in mind that the upper half of the pipe is assumed as a curved beam with a span in inches equal to the mean diameter.

Reinforced concrete is concrete in which steel or iron is embedded in such a manner that each material will properly care for the stresses it is best qualified to care for. It looks reasonable therefore to believe that when one designs a structure in reinforced concrete that the different materials would be properly disposed. Yet the United States Patent Office has granted to Mr. Walter Parmalee a number of patents covering the placing of steel in arches and rings of reinforced concrete in the places where the tension will exceed the tensile strength of the concrete. Therefore if we want to use reinforced concrete sewers we must pay Mr. Parmelee a royalty, or fight his patents, or make our sewers so thick that the steel can be placed in the center of the ring. Or we can [illegible] that we can have two rings of reinforcement, one towards the inner side and the other towards the outer side.

The American Concrete Pipe Co. of Chicago is putting on the market a pipe embodying the Parmelee patents. The reinforcement is bent to a true circle. To get the steel, however, in the proper place the molds are slightly elliptical in shape so the sewer is a trifle higher than it is wide. This is an ingenious way of getting the reinforcement in its proper position without going to great expense for bending and fitting.

The Lock Joint Pipe Co. of New York and the Reinforced Concrete Pipe Co. of Jackson, Mich., make pipes in which the reinforcement is intended to provide against breakage in handling as well as to make the pipes strong enough to do their work in the trench.

For pipes constructed in place, that is monolithic pipes, it is not economical to use reinforcement until they exceed [illegible] ft. in diameter. It is difficult to place in a small pipe and the cost will pay for a lot of concrete. It is therefore best to make plain concrete sewers when the diameter is less than [illegible] ft., provided they are monolithic.

A great industry is being worked up all over the country by manufacturers of machinery, in sewer pipe made in forms and put in place like vitrified pipes. This in my mind is the ideal method of building concrete sewers in sizes that can be handled. The best workmanship can be attained, for we must say that a great many concrete sewers now built in place fall far short of all their designers hoped of them.

For concrete pipes made in sheds or on the bank alongside the sewer trench, no reinforcement is required up to 18 ins. in diameter.

The thickness for such pipes has been obtained for one maker by comparison with vitrified earthenware pipes which stand an internal pressure of 100 lbs. per sq. in. The vitrified pipes, however, were figured with a tensile strength of 600 lbs. per sq. in., whereas the concrete can be figured on for only 250 lbs.

Let t = thickness in inches of shell,

p = pressure in pounds per sq. in.,

d = diameter in inches,

then

$$t = \frac{pd}{500}$$

The reinforcement will be in the middle of the shell and the pipes will be reinforced as hollow concrete beams designed to be lifted by a hook at each end or by a chain slung around the mid length. The thickness can be calculated by any of the formulas already given and the reinforcement placed so that it will lie along the length, thus making of the pipe practically a plain concrete pipe, which will be strengthened to resist pressure by reason of the reinforcement therein, but which will be able to take care of pressure by means of the concrete alone. In such a case it is quite possible that the formula last given for thickness of small plain concrete pipes will be good enough to use in this connection. Comparison might be made with the thicknesses given by Baumeister and Dykerhoff.

Let M = bending moment in inch pounds

= moment of resistance,

S = section modulus in inch units,

f = fibre stress,

then $M = Sf$ and $S = \frac{M}{f}$

The section modulus of a hollow round beam is

$$= 0.098\left(\frac{d^4 - d_1^4}{d}\right)$$

where d = outer diameter,

d_1 = inner diameter.

Having found the thickness of the shell obtain the bending moment due to the weight of the pipe and divide this by the allowable steel fiber stress, for we cannot allow anything for the concrete in tension. The section modulus then obtained is found by assuming some definite thickness of steel and assuming it to be placed in a cylinder within the concrete. This amount of steel of course will have a definite cross-sectional area and this same area can then be obtained in the form of reinforcing metal of whatever kind the user prefers.

I believe that all large concrete sewers of circular section should be reinforced. Plain concrete sewers should be thickened at the sides to resist the thrust from the arched top. The formula of Rankine for thickness of crown of arch can be used, but the top of it should go on a tangent from the critical point. This point is found by a line drawn from the center at an angle of 60° each side of a vertical line through the middle of the crown and the center. The line of thrust of the arch should be calculated and the sides proportioned to care for the thrust. Such designing will give sewers of a somewhat different shape from those to which we are accustomed, but in these days there is a constant breaking away from ill founded precedent.

I am convinced from studies made of many existing sewers that a tremendous amount of reinforcement is being used where it is not necessary and a number of sewers are being put in every day where reinforcement is badly needed. A concrete sewer is not so flexible as a brick sewer. The latter by reason of its joints can alter its shape to accommodate itself to pressures from unexpected quarters and the integrity of the sewer is not destroyed. There is a certain admirable flexibility about a brick sewer not possessed by the monolithic concrete sewer. Concrete is weak in tension and when the arch is loaded in a manner to produce a bending moment cracks will open up. The brick sewer will simply change shape a little and the alteration may never be noticed

In building sewers exceeding 4 ft. in diameter considerable economy can be obtained by the use of reinforcement and this economy becomes more evident as the sizes of the sewers increase.

There are two points for consideration in sewer design affecting the shape. One is the amount of liquid to be carried and the other the economic proportions, both as it affects material used and labor involved, for the cost of forming is something to be reckoned with in concrete sewer work. Whether concrete sewers will be cheaper than brick sewers is a point that can be considered only at the time the work is to be done and cannot be decided hastily It will be found generally that up to 4 or 5 ft. in diameter it will be most satisfactory to have the pipes made and cured alongside the trench and put in place after thorough inspection Do not attempt monolithic work until convinced it is the cheaper.

Contrary to the preliminary reports that have been issued, the cement production in the United States in the calendar year 1908, shows an increase over the production in 1907. According to a preliminary report of the production for the past two years was as follows:

	1908. Bbls.	1907. Bbls.
Portland	51,002,612	48,785,390
Natural	1,621,862	2,887,700
Puzzolan	151,451	557,252
Total	52,775,925	52,230,342

Railway Section

Note: This section is devoted to methods and costs of constructing railways. It will cover road-bed and track construction, contractor's plant and organization, surveying methods and permanent way structures.

The Detailed Cost of Elevated Railways in Brooklyn and New York.

The following table gives costs of building double track elevated railways in Brooklyn during three different periods:

Year.	1885 to 1888.	1888 to 1891.	1892 to 1903.
Miles of structure built	5.6	5.4	3.22
Number of stations	14	19	9
Total net tons iron	19,488	16,203	10,980
Average net tons per mile	3,473	3,001	3,055
Maximum net tons per mile	3,578	3,566	3,287
Minimum net tons per mile	2,907	2,842	2,824
Cost of iron per ton	$ 79.00	$ 68.68	$ 61.00
Cost of each foundation	187.70	140.90	93.50
Total cost per mile	542,441	332,352	297,599

In explanation of the high cost of foundations it should be stated that, from 1885 to 1888, a brick foundation pier with a bluestone cap and cast iron base was used under each post or column. During 1888 to 1891 concrete was substituted for the brick, but the cast iron base (below the street level) was retained. In 1892 and 1893, the cast iron base was abandoned, and the columns were designed to rest directly on the concrete at the street level.

The 3.22 miles of structure built in 1892-1893 included 2800 ft. of third and cross-over tracks, and the following were the average unit prices:

Excavation (per cu. yd.)	$ 0.50
Concrete (per cu. yd)	7.00
Steel in structure (per net ton)	61.00
Timber (per M.)	21.00
Steel rails, per gross ton (85 lb. per yd.)	31.00
Labor, laying single track (per ft.)	0.35

The following gives the detailed costs per mile of structure:

	Per mile of double track.
200 foundations (1,900 cu. yds. concrete) including bolts	$ 18,649
3,055 net tons iron in place	184,423
Double track, materials and labor	43,248
Stations	38,819
Engineering	9,934
Miscellaneous	2,526
Total	$297,599

There are 683,670 ft. B. M. timber per mile, in ties, guard rails, etc., which, at $21 per M., is equivalent to $14,357 per mile for timber.

It will be noted that engineering cost 3.35% of the total, and that the average weight of steel in the structure is 1,157 lbs. per lin. ft., and that the average span length of the plate girders is about 53 ft. Considering merely the cost of materials and labor, a span of 30 ft. would have been the most economical, and would have resulted in a saving of 5%, considering only the foundations and superstructure, but the longer span (53 ft.) was adopted to reduce damage to abutting property.

The maximum work of erection in 10 hours was 12 spans of 52 ft. each, weighing 315 tons; an average of 8 spans per day was easily maintained.

In the track land prior to 1888, the ties were 6x8 ins., spaced 22 ins. c. to c., and the rails were 60 lb. A 6x8 in. guard timber was bolted each side of each rail. In 1888, the ties were made 7x8 ins., spaced 16 ins. c. to c., and the rails were still 60 lb. In 1892 an 85 lb. rail was adopted, to secure a longer life of the rail and to reduce the cutting of the rails into the ties, and the ties were spaced 15 ins. c. to c.

The contract prices for stations were about as follows in 1893:

	One stairway.	Two stairways.
Carpenter work	$3,095	$3,578
Sheet metal work	1,432	926
Painting and decorating	409	540
Plumbing work	225	296
Heating apparatus	225	295
Architectural work	2,100	2,200
Total	$7,467	$7,835

These were ordinary inter-track stations. It is a serious economic mistake to build two stations outside of the tracks, instead of one between, as it doubles not only the first cost but the cost of station service and maintenance. Station service and maintenance cost $2,400 a year per station.

Terminal stations, containing trainmen's rooms, etc., cost about double the above.

The cost of operating 16.9 miles of road in Brooklyn in 1893 was as follows:

Maintenance of way and structures:		
Repairs of track and structures	$	38,316.59
Repairs of stations, shops, etc.		13,032.29
Other expenses		425.30
Total	$	51,774.18
Maintenance of equipment:		
Repairs of locomotives	$	40,317.29
Repairs of cars		53,039.53
Repairs of machinery and tools		1,730.76
Other expenses		11,847.72
Total	$	106,935.30
Conducting transportation:		
Wages of conductors and guards	$	99,343.85
Wages of engineers and firemen		205,180.83
Fuel for locomotives		246,131.53
Oil and waste		6,085.92
Water supply		12,661.38
Other train expenses and supplies		16,585.73
Wages of station agents, gatemen, etc		158,331.71
Station supplies		7,893.11
Wages of flagmen, switchmen, etc.		25,600.48
Other expenses		67,225.84
Total	$	845,040.38
General expenses:		
Salaries of officers and clerks	$	32,247.55
General office expenses and supplies		809.30
Stationery and printing		6,746.94
Advertising		144.80
Legal expenses		16,574.05
Damage to property		915.08
Damage to persons		14,434.74
Telegraph maintenance and operation		1,195.69
Other expenses		14,595.55
Total	$	87,963.70
Grand total operating expenses	$	1,091,713.56

The operating expenses were 56.82% of the gross receipts.

There were 38,110,376 passengers carried.

There were 50 stations in the 16.91 miles.

There were 76 engines and 230 cars to operate the 16.91 miles of elevated road. This is equivalent to about 4.5 locomotives and 13.6 cars per mile of road.

In ENGINEERING-CONTRACTING, Oct. 7, 1908, the cost of 35 miles of double track elevated railway built on Manhattan Island prior to 1880, was given as follows per mile

Foundations, columns, superstructure and track	$288,400
Stations	60,000
5 locomotives at $4,000	20,000
12 cars at $3,300	39,600
Total	$408,000

It will be noted that the equipment cost nearly $60,000 per mile.

It the locomotives and cars cost the same for the Brooklyn lines, it will be seen that the cost of locomotive repairs was 13 per cent of the first cost, for that item amounted to $530 per locomotive during the year 1893. The cost of car repairs amounted to $230 per car for 1893, which is about 7 per cent of the first cost

Our Oct. 7, 1908, issue gives the distribution of steel in the various parts of the Brooklyn elevated railways built in 1893, as follows:

	Per cent.
Columns	11.5
Transverse girders	20.5
Longitudinal girders (two tracks)	57.0
Station platforms	5.0
Bracing	6.0
Total	100.0

It is also stated that the locomotives weighed 45,000 to 56,000 lbs., the wheel base being 16 ft.

In his Report No. 7 to the Public Service Commission for the First District of the State of New York, Mr. Bion J. Arnold gives the following estimate of the cost of reproducing one mile of single track elevated railway, exclusive of equipment, power plants and electrical conductors:

$200,000 (low) to $300,000 (high).

These figures must be multiplied by 2, for comparison with the actual costs above given, and we then have Mr. Arnold's estimate of $400,000 to $600,000 per mile of double track elevated road, exclusive of equipment. It is clear that Mr. Arnold has grossly overestimated the present cost of reproducing a mile of double track elevated road of the class now in use in New York City. His estimate of $600,000 to $900,000 per mile of single track subway (exclusive of equipment) is also far too high, as we shall show in a subsequent issue.

The Method of Appraising the Land Value of the Michigan Railways.

The two letters that follow speak for themselves, and contain matter of interest not only to engineers who are likely to be engaged in railway appraisals but to engineers who may be called upon to appraise real estate and other property for taxation purposes.

Sirs —In connection with some of your statements relative to the appraisal of the Michigan State Railroads made some years ago, you discuss admirably the element of real estate values and the methods which you think best to follow.

I gather that you are not quite as familiar with the methods finally employed in this work, because they were so in keeping with your own ideas and even went them one better that it is a pleasure for me to call it to your attention, knowing that you are highly appreciative of original work of this kind, and will be pleased to see that this particular expert's ideas and methods follow your own so very closely and yet carried out with a little different method as to details; for precision of detail and speed of accomplishment was only possible to a very well defined and carefully considered method entirely and exclusively evolved by Mr. Edward A. Dunbar, a former West Pointer and expert engineer, and well acquainted with real estate matters himself in large enterprises.

For economy of costs and in the completeness of the returns I think it is unexcelled, and has never been approached by any other equally reliable method, except your own; but all of them are much the same and splendid in their discussion of a very difficult and what has heretofore been a vexatious problem to solve

I hope some time in the near future to have the great pleasure of meeting you personally, for we highly appreciate your method of thinking about a good many things.

There has been in all this property so much theoretical stuff injected into it that it is very wearisome to practical men, and it is a relief to find some one like yourself who has the courage and the earnestness of purpose and honesty of intention to say so.

Yours truly,
F. T. Barcroft,
Director of Appraisal.

Detroit, Mich., April 26, 1909.

My Dear Mr. Barcroft:—In compliance with your request I submit herewith a statement of the method by which the land values of the Michigan Railroad Appraisal were deduced.

LAND VALUATION.

The limited time in which full results had to be made known precluded the general adoption of any of the usual methods of land valuation and for that reason the following method was adopted:

Determining the Quantity.—The office inspectors, as they were called, took direct from the maps and other data of the railroad company, and of the registers of deeds offices, all the information necessary to determine the area of the railroad land throughout the state. They subdivided the land, in taking it off by counties and also subdivided it so the right-of-way between stations showed separately from the right-of-way and additional land at stations, or at points where the density of population would enhance the values of land beyond that of farm land.

In the cities the land was all divided into small blocks, so that it might be estimated either by square feet or by the front foot, as might seem most expedient.

Determining the Quality.—As the land throughout the state is not uniform in quality the railroads' lands were subdivided into 83 subdivisions—following county lines. And on the basis of its physical characteristics, it was also subdivided into six separate classes, viz:

1st. Farm land.
2d. Barren land.
3d Towns under 500 population.
4th. Towns under 3,000 population.
5th. Towns under 10,000 population.
6th. Towns over 10,000 population

To determine the percentage on each railroad in each county of farm and waste land a representative was sent to each of the railway centers of the state. He interviewed roadmasters, assistant roadmasters, locomotive engineers and freight train conductors, as being men who knew every foot of the land over which the railroad passed and from them secured the information which enabled him to report on the percentage of waste land on each railroad by counties

In the smaller cities and a few of the larger villages the quality of land was determined by our representative going over the land within the city, dividing it up according to the use to which the various sections were put, viz

Laborers' residence property
Mechanics' residence property.
High class residence property
Manufacturing residence property
Second-class store property
First-class store property

He also got local experts to value each division, but this really falls under the next head which is:

Determining the Price —The price of the land in the first five classes, except as next before noted, was determined by sending a letter of inquiry, enclosing a card for reply, to some five hundred representative citizens of the state, taking about six from each county and choosing these citizens from among land dealers, bankers, county surveyors and county treasurers Each man selected was supposed to be peculiarly adapted as a judge of land values within his county and on the card enclosed was requested to give his estimate of the present value of an average acre of land in his county in each of the five classes

This method it will be observed assumes that every acre of land of the same class, in a county, is equally valuable and that that value may fairly be taken to be the average price of the land of that class in that county. An average of the prices by classes as given on the cards for each county was therefore taken as the present valuation for the first four classes and partly for the fifth For part of the fifth and all of the sixth, the price was determined in the usual manner by a board of experts, going over every foot of the property in question and valuing each piece separately, taking into consideration surrounding values, both from selling prices of adjoining land and assessment rolls.

Our method of accumulating this information was by means of a card index file, of which I enclose a sample card One card was made for each county through which each railroad passed. It is evident therefore that by applying the average prices to the class quantities, determining as hereinbefore described, that each card would represent the total present market value of all the land belonging to the railroad in question in that particular county, and the sum of the values given on all the cards, for any given railroad (that is one card for each county) would equal the actual present market value of all the land owned by that railroad in the State of Michigan and that the total of all the cards would equal the total present value of all the railroad lands in the State of Michigan.

The question arose in our minds at the outset whether in addressing five hundred strangers, nearly all of whom were busy men, we should get any considerable number of replies to our inquiry and if we did, whether they would not be mere offhand guesses rather than thoughtful estimates. It is extremely gratifying to be able to say that out of five hundred cards sent out less than fifty have failed to respond In only one case was the failure to comply with the request based upon the plea of no compensation, and of all the answers received there is scarcely one that does not bear either in itself, or in an accompanying letter, evidence of the most painstaking care It was noticed in many instances that before making out his card the writer would correspond with from five to twelve different persons in his county, getting their views and then summarizing them on his card

I do not believe that had we gone over every acre of the land in this state, with a board of inspection and valuation, at enormous expense, we would have arrived at any better result than we did by the inexpensive and expeditious method detailed above

Yours very truly,
F. C. Dunbar

Bridges, Buildings and Foundations

Note: This section is devoted to methods and costs of constructing steel and masonry bridges and buildings and of foundation work of all kinds. It will give special attention to erection plant and tools, falseworks and centers and cost data of all kinds.

Comparative Estimates of Cost of Four Types of Culvert for the Same Drainage Opening.*

The question of relative economy in the cost of construction of various types of drainage openings often arises. Below are estimates of the cost of four types of construction for the same drainage opening on the Madisonville, Hartford & Eastern R. R., now under construction in Western Kentucky. The unit prices used in these estimates are those paid by the railroad company to the contractors doing the construction work. Therefore the cost estimates are on the basis of cost to the railroad company having the work done, and not on the basis of actual cost to contractors.

The general character of the surrounding country at the opening in question is hilly and covered with thick woods. The opening itself is in a fill containing 48,000 cu. yds. of material, there being 33 ft. of filling at the culvert, the total length of fill from grade point to grade point being about 1,000 ft. The water passing through the culvert is normally a small brook, which empties into Rough river about 300 yards below the railroad fill.

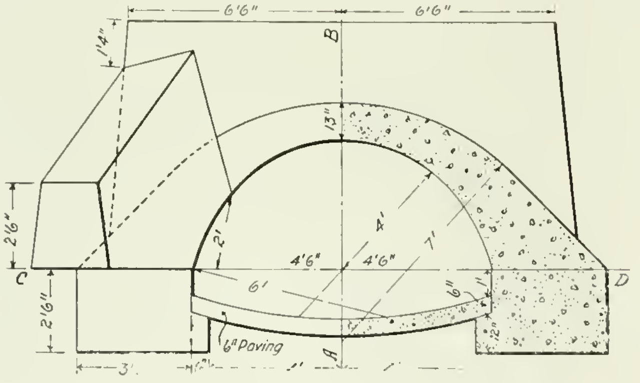

Fig. 1—Concrete Arch Culvert.

ESTIMATE NO. 1.

Structure.—A 9-ft. concrete arch culvert of cross-section, as shown by Fig. 1. This is the structure that has been built by the railroad company. The concrete in the foundation or below plan *C-D* and in the wings and head walls was mixed in the propostion of 1-3-6. The concrete in the arch or above plane *C-D* was mixed in the proportion of 1-2½-5 in order to obtain additional strength in the arch wing.

Foundation.—The foundation for the culvert was not altogether satisfactory. The soil at the opening was underlaid by a mixed stratum of dirt and gravel, and under this ordinary clay. It was thought best to place the foundation on the gravel strata instead of moving the same and greatly increasing the cost of structure by digging to rock or using piles. To aid in distributing the pressure, an offset of 1 ft. wide and 1 ft. deep was made on the outside of each bench wall for 18 ft. each side of the center of the track (this in order to "take up" the greater pressure directly under the roadbed). The paving for this culvert was also increased from a thickness of 6 to 12 ins., and arched downward, as shown in the sketch. Reinforcing of paving by wire fencing running from wall to wall was also considered.

The experience of the chief engineer, Mr. George W. Feagin, has been that culverts founded as this one fail somewhat in the following manner: First, the building of such a high fill puts an enormous weight on the original ground surface immediately beyond each bench wall. The earth at this opening is of a rubber-like description, and the great stresses imposed on the earth surface on either side of the fill are transmitted somewhat as in water pressure or hydraulics where pressure is equal in all directions. In the failure of a culvert this pressure goes down under the bench walls carrying the weight of the fill, and pushes upward on the paving. If the paving is not strong enough it cracks; and this cracking of the paving destroys the homogeneity of the structure and throws additional weight to one of the bench walls. This additional weight in a case of complete failure causes the wall to settle, and thereby cracks the arch above. The actual cost to the railroad company of building the 9-ft. arch of concrete is as follows:

238 cu. yds. of concrete masonry, at $8.50	$2,023.00
387 ton-miles of concrete hauled, at 60c	232.20
656 yards-miles of sand hauled, at 60c	393.60
418 cu. yds. of dry excavation at 40c	167.20
Total	$2,816.00

Therefore the total cost to cost per cubic yard of concrete equals $11.83. Also an additional sum of probably 50 cts. per yard for inspection should be charged to this masonry. This inspection charge is for one man in addition to the regular residency force. This man's time at the culvert was about two months. The cement used was a Portland cement made in St. Louis and hauled from the nearest railroad station on the Illinois Central R. R. In calculating cement and sand hauled, one mile is considered free haul. The total distance from the railroad station to the culvert is 8.4 miles, or 7.4 miles pay haul. The length of the culvert from face to face of head wall is 95 ft. The sand for the concrete was also hauled from the railroad station 8.4 miles distant. All of this hauling was done on dirt roads during October and November, 1907, when the roads were in very bad condition. (The roads of this part of Kentucky are as bad as can be found anywhere.) The total number of sacks of cement used was 1,101. The sand used amounted to 89 cu. yds. The item of dry excavation was bid by the contractors for all excavations for pipe and culvert foundations and such excavation for bridge foundations as would not be classed "water excavation." The work was done by a subcontractor in November and December, 1907, under very bad weather conditions. The contractor was not allowed to lay or mix any concrete in freezing weather, and was required to quit work on afternoons at least 1½ hours before the time at which it was estimated the temperature would reach the freezing point.

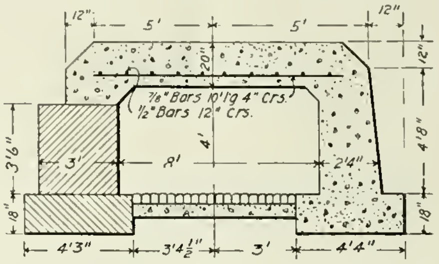

Fig. 2—Reinforced Concrete Box Culvert.

ESTIMATE NO. 2.

Below is tabulated an estimate of the cost of a 4 x 8-ft. reinforced concrete box culvert for the same opening as above:

1. 72 cu. yds. of reinforced concrete (1-2½-5), at $9	$ 648.00
2. 122 cu. yds. of plain concrete (1-3-6), at $8.50	1,037.00
3. 18 cu. yds. of stone paving (cobbles), at $3.50	63.00
4. 6,560 lbs. of iron in reinforced concrete, at 5c	328.00
5. 577 yards-miles of sand hauled at 60c	346.20
6. 310 ton-miles of cement hauled, at 60c	186.00
7. 400 yds. of dry excavation, at 40c	160.00
Total	$2,768.20

Reinforced concrete in the above estimate includes all concrete in the culvert top or above a horizontal plane 3½ ft. above the paving. (See sketch, Fig. 2.) Plain concrete includes all concrete below this plane and in head walls and wing walls. The sand and cement hauls in the above were, of course, calculated from the same railroad station as in estimate No. 1.

ESTIMATE NO. 3.

The structure of which the cost is estimated in estimate No. 3 is an ordinary 4 x 8-ft. box culvert, with a reinforced top, as shown by Fig. 3 (paving cobblestone).

1. 74 cu. yds of reinforced concrete (1-2½-5), at $9	$ 666.00
2. 118 cu. yds. of box culvert masonry, at $6	708.00
3. 19 cu. yds. of paving (cobblestone), at $3.50	66.50
4. 6,560 lbs. of iron in reinforced concrete, at 5c	328.00
5. 220 yard-miles of sand hauled, at 60c	132.00
6. 105 ton-miles of cement hauled, at 60c	63.00
7. 400 yds. of dry excavation, at 40c	160.00
Total	$2,123.00

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*A paper by E. W. Cooper read before the Engineering Association of the South.

No haul on stone is estimated in the foregoing estimates, for the reason that a suitable stone for concrete and walls is within 3,000 ft of the opening. A quarry was opened at this place, and the stone for concrete was crushed by a portable jaw crusher running 40 cu yds of crushed stone per day.

ESTIMATE NO. 4

An ordinary double 4 x 4 ft box culvert as shown by Fig. 4, is the structure in estimate No. 4.

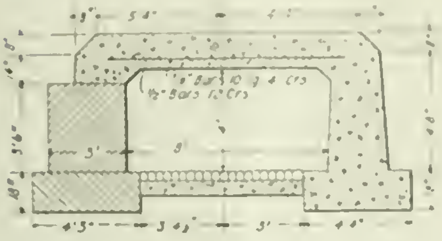


Fig. 3—Reinforced Concrete Box Culvert.

220 yds. of box culvert masonry, at $6	$1,320.00
24 yds. of paving, at $3.50	84.00
100 yard-miles of sand hauled, at 60c	60.00
50 ton-miles of cement hauled, at 60c	30.00
400 yds. of foundation excavation, at 40c	160.00
Total	$1,654.00

SUMMARY OF ESTIMATES.

The four estimates are summarized in table 1. No. 1 is the 9-ft. concrete arch culvert. No. 2 is the 4 x 8-ft. reinforced concrete box culvert. No. 3 is the 4 x 8-ft. box culvert, with reinforced top, and No. 4 is the 4 x 4 ft. double box culvert.

On inspecting the above summary, it is seen at once that the double box culvert of estimate No. 4 would have cost the railroad company less than any of the other structures estimated. The use of a 4 x 4-ft. box was contemplated, but abandoned on account of the inability to find suitable cover stone. The difference between estimates No. 1 and No. 2 is very small, indicating that either structure could have been used in so far as regards first cost. It should be noted, however, that No. 1 provides a semi-circular opening, and, therefore, gives greater discharging capacity than No. 2, a rectangular opening. Therefore, No. 1 would probably be preferable to No. 2.

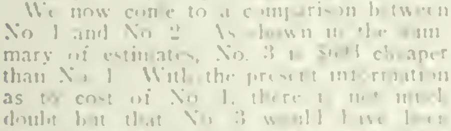


Fig. 4—Double Box Culvert.

We now come to a comparison between No. 1 and No. 2. As shown in the summary of estimates, No. 3 is $[illegible] cheaper than No. 1. With the present information as to cost of No. 1, there is not much doubt but that No. 3 would have been more economical and should have been used. The haul on sand and cement for No. 1 was before beginning work, figured from a point four miles pay haul from the opening. It was contemplated to deliver material at this point by boat from Evansville, Ind. It was found after beginning work that this arrangement would have to be abandoned on account of the "hold up" tactics resorted to by the river men. Therefore the haul on sand and cement was doubled, and the cost of No. 1 increased beyond that of No. 3.

In concluding, attention might be called to the following facts. (1) There is at present a tendency to use concrete on every occasion where its use is at all permissible. (2) The haul on sand and cement and stone often forms a considerable percentage of the cost of concrete. (3) Concrete cannot, with present contract prices, compete with box culvert masonry in localities where suitable stone for box culvert masonry can be procured within a reasonable distance.

TABLE 1

No. of estimate	Area of waterway opening Sq. ft.	Shape of waterway opening	Total No. cu. yds. masonry required	Total cost to railroad company	Remarks
1	[illegible]	Semicircle	[illegible]	$[illegible]	[illegible]
2	32	Rectangle	[illegible]	[illegible]	Estimated cost
3	32	Rectangle	[illegible]	[illegible]	Estimated cost
4	32	Rectangle	[illegible]	1,6[illegible]	Estimated cost

LETTERS TO THE EDITORS.

The Panama Canal.

Sirs: "The Panama Canal" is the subject of more thought, time, money and conversation than any other subject before the American people to-day. We hear everywhere queries such as: Will it be built? Will it be a failure? How much will it cost? How long before it is finished? After walking mile after mile through the hot blazing sun from Bas Obispo to Paraiso, where the principal deep cut is made, and watching the ground move, I would unhesitatingly say: Yes it will be built. It may be a little behind time, but it will be built. Without a doubt it is the most stupendous undertaking since this old world started whirling. It is almost impossible to convey to one who has not studied the subject closely the difficulties of every description that had to be overcome before the work of digging the canal could be started. Imagine a jungle alive with mosquitoes and insects of all kinds, venomous snakes, flies, in fact everything to make life miserable.

The towns along the route even to Colon, or Aspinwall as it was called, a mass of mire and mud, the streets knee deep in mud and filth, no sanitation (the natives never heard of that word before the Americans came) such was the condition when the French tried to dig the canal (and died like flies), and such were the conditions when the Americans took up the task of connecting the Atlantic with the Pacific. First it was necessary to put the Isthmus in a sanitary condition so that a white man could live there.

The Sanitary Squad.—These heroes of the Jungle, deserve as much praise as the engineers who solved the engineering problem. But with all these poor conditions the French accomplished a great amount of work, more than the majority of people in the United States are aware of. They were working for a sea level canal, and while a sea level canal would be better than the lock canal, the difficulties, time and expense of making, are not to be thought of at the present time. It is better to let future generations take care of that for the canal is needed quickly and the wise heads of this nation know why. Naturally in an undertaking of this size there are always kickers and sore heads, but they are like flies bothering a fine horse, irritating but not fatal.

I will give a brief description of the canal as I saw it and as truthful as I can remember. Around Colon everywhere are to be seen the activities of the Americans, but no great problems are to be solved here. Coming to the Gatun Dam, this bone of contention, such as underground lake, 500 ft of mud, stratified rock, etc., this great fill which is going to make the dam is going to be so large and contain so much material that its very weight will be the means of suffocating the underground lake, squeezing the mud out of existence, holding down the stratified rock, and make every liar that has seen "the dam going out into the sea" sneak into his hole and pull the hole in after him. The great dam will be about a mile long, a half-mile wide at the bottom and about an eighth mile wide at the top; a young mountain thrown into a valley that the Chagris River will never move. When the dam is finished, and the waters of the Chagris River are held back there will be no sudden rise of the river as there is now, caused by the heavy rains and creating a terrible force of water. After the dam is finished it will be like pouring water into an immense tub and letting it run out of the other side over the spillway and thereby losing its force. When this artificial lake is formed it will reach to Bas Obispo and from there starts the Herculean feat of cutting through a mountain, Gold Hill being the highest cut, from the bed of the canal to the top it being nearly 900 ft. From Bas Obispo to Paraiso is the greatest excavating, the rock is of such a nature in a great many places that it requires drilling and blasting, but the largest amount is taken out by the Giant steam shovels, as with but two or three exceptions the whole Isthmus is volcanic ash, compressed and of such a nature that it breaks and slides. The average person's conception of the canal is a cut through the mountain, like a canyon of the West, but in reality it is a ditch at an angle so sloping that the earth cannot of its own weight slide toward the center. Standing on the top at Empire it seems almost impossible that human beings ever dug through such a mountain. On the Pacific side walls have practically been extended to [illegible] for nearly two miles so that it can be dredged and made deep enough without its filling in from the action of the waves. The same length and height of locks are required on the Pacific side as on the Atlantic. The rock for the Gatun dam is taken from Porto Bello, [illegible] down the coast from Colon and is as fine a quality as the Staten Island or Palisades trap rock and will withstand the elements for a thousand years or as long as the mosquitoes will stay in New Jersey as they were all sent from Panama to Jersey. I do not know what can be said [illegible] in Panama having never [illegible]. I will predict that Panama City and along the canal from Bas Obispo to Paraiso will be the favorite summer resort for thousands of Americans during February and March after the canal is finished. In conclusion, I will say the canal is being put through by the best methods, and by as skilled and competent a lot of men as was ever my good fortune to meet. Their hospitality and kindness to a stranger in a strange land will never be forgotten.

WALTER WOOD.

Wood Drill Works, Paterson, N. J., April 16, 1909.

Unlicensed Engineers in Missouri.

Sirs—Noting with interest the discussion in your columns relating to licensing engineers, it appears to me that Mr. Tupper's position (Engineering-Contracting, April 21, 1909) that engineers employed by the public should be licensed is the correct one.

On January 1, 1908, a law went into force in Missouri which requires that in each county the county judges,—equivalent to county commissioners in some states,—shall appoint a county engineer, who shall have charge of the roads, bridges, culverts, etc. He is to make a map and show on it the various road districts, which are to be in direct charge of a foreman under the general supervision of the engineer.

Now as a rule, the county judges are wholly incompetent to pass on the qualifications of an engineer. In more than one case within the writer's knowledge the appointee is wholly devoid of any engineering training; cannot make a map that is intelligible; cannot run a set of levels over a thousand feet of country road, plat a profile of same and put a grade line on it; cannot properly stake out work in the field or design and make plans of anything that anybody could tell anything about.

The county engineers are supposed to be under the general supervision of the state engineer, but this cannot be very close over 115 counties, not to mention his other duties.

For a board to pass on their work appears to me to be entirely impracticable; it would frequently cost more than the work. There is no such board at present.

The law seems to be a sort of stagger in the right direction, but in many cases the results will be very poor until the county engineer is required to come up to some sort of standard of efficiency.

Yours truly,
E. K. Blanchard.

St. Louis, Mo., April 24, 1909.

Is $23,500 a Fair Average Value Per Mile of American Railways?

Sirs: My attention has been called to an editorial in your issue of March 31 criticizing a paper which I wrote some time ago for the Terre Haute Science Club.

It does not seem quite fair to quote two isolated paragraphs from a paper without defining the terms used. In my paper the term "present value" was defined as representing the cost of reproducing the physical properties of the railroads minus the depreciation up to the time of valuation. This is quite different from the commercial valuation. The latter was also given in my paper.

In the Minnesota valuation to which you refer, two estimates are given, one based upon an allowance of three times the value of the land used for right of way, the other based upon the actual value. Also the cost of reproduction without allowance for depreciation is given as well as the "present value." The values vary from a maximum of $49,635 per mile of all main tracks to a minimum of $37,461, the minimum value representing the "present value" (in the sense used in my paper) and with real estate valued in proportion to contiguous property.

The average value per mile of the railroads in Texas as given in the last report of the State Railroad Commission is $17,015. The findings of the Railroad Commission of Washington do not appear to summarize the valuation so that the results are readily available.

One explanation for the high valuation of railroads in Minnesota is to be found in the fact that it contains large and expensive terminals for two transcontinental lines. The average cost of reproduction given for seven railroads operating 1,225 miles of main track in Minnesota, but which have no terminals in St. Paul, Minneapolis or Duluth, is given as $25,398 per mile when the right of way is valued in proportion to contiguous property. For every state which has large and expensive terminals such as Minnesota, Illinois or New York, there are a number of states which have none. In Michigan and Wisconsin the large railroad centers handle chiefly the business of the state and not that of a half dozen states as in the case of Minnesota.

While the figures, $23,500 per mile, might need modification in accordance with changes in costs of labor and material, I am still of the opinion that the average of two states situated as are Michigan and Wisconsin will represent the average for the entire country better than either Minnesota or Texas, and that it furnishes the best obtainable "present value" per mile of railroads in this country.

Yours very truly,
Frank C. Wagner.

Terre Haute, Ind., April 26, 1909.

[We take pleasure in publishing Professor Wagner's reply to our editorial. In comment and answer we may note that the value per mile including land found by the Railroad Commission of Washington is fully as great as that obtained in the Minnesota valuation. In respect to the charge due to expensive terminals in Minnesota mentioned by Professor Wagner it may be said that expensive "terminals" exist in every well settled state, for the word terminal includes all stations and yards in *all cities*. Moreover, if we deduct from the Minnesota valuation all land values of all roads the average obtained is far in excess of $25,000 per mile.—Editors.]

An Unsolicited and Much Appreciated Testimonial.

Sirs: In connection with your two recent issues of Engineering-Contracting, I have been very much interested, in reference to engineering articles contained therein, and wish to express my appreciation for your valuable publication.

Yours truly,
T. W. Whitney,
Division Engineer.

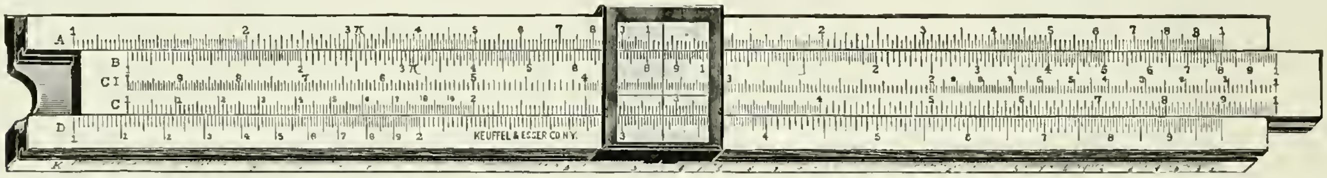
New York, Susquehanna & Western Railroad Company, office of Superintendent, Jersey City, N. J., May 1, 1909.

The output of the two principal coal producing departments of France—Pas-de-Calais and the Nord—in 1908, was 25,521,606 tons, an increase of about 780,000 tons over 1907.

A Polyphase Slide Rule.

A novel style of slide rule capable of performing a wide variety of calculations has recently been placed on the market by Keuffel & Esser Co., New York. The new rule is illustrated by the accompanying cut. It is made in a similar form to the ordinary Mannheim slide rule, being a little wider in order to accommodate an extra scale upon the slide. In addition to the regular *A*, *B*, *C*, *D*, and trigonometrical scales of the ordinary slide rule, the Polyphase has on the face of the slide an *inverted C* scale between the *B* and *C* scales, and on the edge of the rule in place of the millimeter scale is placed a scale of cubes.

This arrangement enables squares and square roots, cubes and cube roots and a wide variety of combinations, such as the 4th, 5th, 7th and 11th powers and 6th roots to be taken with one setting of the slide, and the position of the inverted *C* scale on the slide enables many problems involving three factors to be performed at one setting also. The advantage of this arrangement lies not alone in the lessened time required to work an example, but also in the increased assurance of accuracy due to a fewer number of settings. In a circular which is furnished with this rule 70 different examples, showing a wide variety of problems involving roots, powers and combinations, illustrate the manifold uses to which the Polyphase slide rule may be put. Nor, it is claimed, are these difficult, as the arrangement of the scales is so simple that their relations may be readily grasped and new combinations especially applicable to the particular work in hand easily worked out upon them.



Various methods of applying preservatives to railroad ties and telegraph poles have been in use in Europe for more than 30 years. Published figures from 20 German telegraph lines, the treated poles of which were set at various intervals from 1877 to 1893, show that of those set in 1877, 30 to 38 per cent were still sound and in use after 26 years' service. Of the poles set from 1891 to 1893 records from five lines show that all of the poles are still standing.

Drainage work in Texas will be materially aided by two bills that have just been signed by the governor. One of these makes an appropriation of $50,000, which will be increased by a similar sum furnished by the federal government, for a topographical and hydrographic survey of the river valleys and coastal planes of the state, while the other provides for the creation of levee districts. It is expected that these two acts will furnish the necessary information and legal machinery for reclaiming large tracts of valuable land which at present are but slightly developed, although their capabilities are recognized.

The United States dredge "Clatsop," which started from Philadelphia December 9, 1908, for a 17,000-mile trip around Cape Horn to Portland, Ore., reached that port April 20, making the voyage under her own steam in 132 days, 54 of which were spent in various ports taking on coal and supplies.

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A Neglected Form of Advertising.

A form of outdoor advertising which might be employed more frequently than it is and which has none of the aesthetic viciousness of a bill board set in a fair landscape, is a legible sign attached to a factory or an industrial plant, where it can be read from railway trains and adjacent highways. It is surprising how many owners of manufacturing plants fail to erect such signs and even more surprising how frequently during a railway journey one hears the questions: What plant is that? What do they make? A properly displayed and worded sign would answer both these questions and serve to locate the firm and impress its product on the minds of hundreds of persons at the very time when curiosity is most active and consequently memory is the most impressionable. The sign should give the firm name, the name of the town or city in which the plant is located and the name or character of the product manufactured.

The Discussion of The Paper by Professor Ebenezer Emilius Saxifrage, D. Sc.

The deliberations of a body of scientists and technicians in formal convocation were burlesqued a great many years ago by that master of the art—Charles Dickens. We have not read the papers and discussions before the "Mudfog Association" for a great many years, but we have at various times been reminded of them when "sitting out" a session of some technical society meeting in wait for that scrap which would make practical "copy" for the engineering journalist. The same recollection is again aroused by a letter which we find in a recent issue of "The Engineer" of London, England. This letter is worth printing for two reasons, not the lesser of which is its humor. Perhaps we should explain beforehand, however, that this letter is a portion of a discussion which is now being waged among our English cousins of the engineering profession regarding the unpractical and useless character of the papers being published by the Institution of Civil Engineers. We have no part and only general interest in this debate, but we do give space to the letter mentioned both because of its humor and because of the lesson that it has to teach to the managing officers of American technical societies. Those who have an inclination to inform themselves further in regard to the controversy will find it outlined more fully in "Engineering News" of April 29, in which the following letter is also printed.

Sir: The following particulars of a paper and discussion, which I heard in the latter part of last year, will perhaps interest some of your readers taking part in the correspondence now going on in your columns. I went to the meeting at the invitation of a friend.

You will remember, no doubt, the establishment about fifty years ago of the Institution of Universal Engineers, intended to [illegible] [illegible] of men in the drawing office, managers and foremen. The [illegible] for a higher [illegible] stimulated. [illegible]

The title of the paper was "An Inquiry into the [illegible] Influence of the Kinetic [illegible] of [illegible] to the [illegible] of the [illegible] of High Pressure [illegible]," by Professor Ebenezer Emilius Saxifrage, D. Sc. of [illegible] College [illegible]. There was a very good attendance, and there were eight members of the Council present.

The president, after some usual routine business, expressed his regret that Professor Saxifrage was unable to be present, but the secretary would now read the paper.

It consisted of 72 pages of close print bristling with formulae and seven sheets of diagrams. The secretary spent about an hour in picking out bits of text which he read and then sat down.

The president said that he felt that the Society was to be heartily congratulated on receiving such an extremely valuable paper from a man in so distinguished a position as Professor Saxifrage's, and he called upon the audience to accord the author, with acclamation, a special vote of thanks. This was given with tumultuous applause. The president then said that the meeting was open for discussion.

I did not notice that there was any alacrity manifested by members in availing themselves of the president's invitation. After a pause, however, a member stood up in the body of the hall, and was about to speak when the president interfered and requested him to come to the platform. The member said it was unnecessary, as he only wanted to ask a question. After some wrangling, however, he went to the platform and then said that he only wished to ask some one to tell him whether the discussion was likely to be over before the last train went. No one seemed to know, so he got off the platform, took his hat, and went away.

Another speaker then rose and said that he felt certain that a more valuable paper could not possibly be written, and for his own part he thanked Professor Saxifrage for it from the bottom of his heart. He felt that where all was so good it might seem hypercritical, but it seemed to him that the printer had misplaced a bracket on pages 7 and 8. At all events, there was an expression there, and he found one bracket on page 7 near the top and another on page 8 near the bottom. Assuming that the printer had not made a mistake he ventured to say with some diffidence that a bracketed quantity which extended two pages might perhaps be considered unwieldy. This was, however, only a matter of opinion. He would not occupy any more of the time of the meeting, but before sitting down he must again express his gratitude to the writer.

The next speaker, a [illegible] gentleman [illegible] wearing [illegible] gold spectacles, said he was in a position to say that if the [illegible] with [illegible] Professor Saxifrage [illegible] himself [illegible] would have been [illegible] in the expression of [illegible]. He was proud to say that he had [illegible] with the Professor. He would [illegible] but it was a fact that the Professor had [illegible] the paper was written [illegible] the Professor [illegible] whether of [illegible]. He [illegible] that the [illegible] to [illegible]. [illegible] the Professor [illegible] of a tailor's and

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asking questions, the answers to which he did not appear at the moment to understand, but he took them down in his notebook and would no doubt use them further on. No doubt the ignorance of the Professor might not appear at first sight to add to the value of the paper; but it had already been pointed out by one very eminent mathematician that the man who attacked a problem with an open, ignorant mind was much more likely to reach a satisfactory solution than a man saturated with that prejudice which invariably resulted from an intimate acquaintance with actual facts.

When he sat down, a young man—evidently a student arose. He said he wanted to ask a question, and, to save time, he proceeded to walk to the platform. He took his hat and umbrella with him and a bundle of papers. At last he reached the platform, and began, "Mr. President and gentlemen." He then referred to voluminous notes, which he held in his left hand. After turning them over for an interminable time and dropping his glasses, he said that he was afraid he had left the note he wanted on his seat, and was going back for it when his neighbor picked it up, and it was passed from hand to hand to him. He only glanced at it, and without further preface he said: "The question I have to ask is simply what is this paper about? I have not the least idea. I see a very full meeting of the council, however, and as they have read the paper and accepted it, they can, no doubt, either collectively or individually, tell me what the nth of an Erasmic polar curve is, and what use can be made of it in designing turbine blades?"

A faint attempt at applause was promptly checked. The president then said that as no one else wished to speak, he would close the discussion. He had to apologize in some measure for the paper which was to be read at their next meeting, but it had been set up for some time, and the printer wanted the type. It was by no means of the value or importance of the paper which they had just had the good fortune to hear, being indeed only a short account of experiments made on a new kind of belting, which is a compound of fine steel wire and paper. It could not pretend to possess more than a practical interest. The members would find, as usual, tea, coffee, and cigarettes in the tea room.

I have had, of course, to condense my report, but I have accurately enough given the sense of what took place during a meeting which lasted from 8 o'clock to 10 p. m. Every one seemed quite satisfied.

April 12th. W. Standish.

Bids are to be asked shortly on three additional New York state barge canal contracts. These contracts, which have been approved by the State Canal Board, are as follows: Contract No. 23, for the construction of the canal (land line) from Kings Bend to Genesee River, Monroe County, including construction of two locks, guard lock, culverts and other incidental work, at an estimated cost of about $2,000,000. Length of contract about five miles. Contract 30, for construction of the barge canal from Little Falls to Sterling Creek, a distance of over 14 miles (river and land line), including the construction of lock at Jacksonburg, guard locks and dams. Estimated cost, about $2,500,000. Contract No. 42, for constructing the Erie Canal, from the Herkimer-Oneida county line to the bend just east of the Oriskney road, a distance of 9 miles; the work including the construction of a lock, two bridges at Utica and a bridge at Whitesboro, together with culverts and other structures. Estimated cost, over $1,000,000.

Concrete and Reinforced Concrete Section

Note:—This section is devoted to methods and cost of constructing concrete and reinforced concrete structures. It will cover the selection, testing and proportioning of concrete materials; laboratory tests of concrete; concrete mixing, transportation and placing; fabrication and placing of reinforcement, and form construction and erection. It will also contain articles on new and interesting developments in the design of reinforced concrete.

Hints for Inspectors of Concrete Work.

V.

Concreting.

A decade ago when dry and medium mixtures were almost entirely used, specifications invariably required that concrete should be deposited in uniform horizontal layers and that each layer should be thoroughly tamped. When dry and medium mixtures are used this is still the invariable rule of procedure. Much and probably most of the concrete work done at the present time is done with very wet mixtures that cannot be tamped, and pouring and puddling are now the methods of placing and compacting concrete. The filling still naturally takes the form of horizontal courses, but there is no distinction between individual courses as is the case with separately tamped layers of dry concrete. The pouring is done at different points of the area to be filled, both because the flow of even sloppy concrete is sluggish and time is saved by pouring at several points, and because a streaky concrete is likely to result if flowing from a single pouring point is entirely depended upon to fill the forms. Puddling or slicing take the place of tamping and consist in churning and cutting the wet mixture with rods or slice bars to work out air bubbles, close up pockets, and settle the materials.

Depositing in Buckets.—See that buckets just clear the work when discharged; a drop (1) jars the forms and may displace the reinforcement and (2) tends to produce separation of the stone from the mortar. See that the bucket is not allowed to rest on the reinforcement and in swinging does not accidentally hit the forms or staging. See that the bucket does not leak and spill concrete over the work.

Depositing Through Chutes.—See that segregation or separation of the stone from the mortar does not occur in depositing concrete through chutes. Fear of segregation causes engineers generally to object to chuting concrete into place. The inspector, of course, will be governed by the engineer's decision in the matter. As a matter of fact, however, concrete can be deposited safely through chutes and prejudice against the method is gradually disappearing.

Method of Pouring.—See that the pouring is done at several points over the area to be filled so as to reduce flowing and spreading to a minimum. See that the pouring is so regulated that the rush of the semi-liquid concrete does not sweep the reinforcement out of place. See that shock due to too sudden discharge is avoided.

Time of Pouring.—See that the time elapsing between mixing and pouring the concrete is well within the time of set of the cement. As a rule the elapsed time should not exceed 30 to 60 minutes; some specifications restrict it to 10 minutes.

Tamping Dry and Medium Concrete.—See that the concrete is deposited in even layers not to exceed 6 to 8 ins. in thickness and is thoroughly tamped with tampers heavy enough to thoroughly compact the concrete and bring a film of water to the surface, if a dry mixture is used, and to cause the mass to quake under the blow if a medium mixture is used. If reinforced, see that the tamping is done with particular care to get the concrete around and into close contact with all reinforcing metal and so as not to displace the reinforcement.

Puddling Wet Concrete.—See that the puddling is thoroughly done so as to work out air bubbles and pockets and bring the concrete into close contact with the reinforcement at every point. See that the poles or slice bars are small enough to enter well into the spaces between and around the reinforcement. See that care is used not to strike the reinforcement and displace it.

Pouring Slabs.—See that the full thickness of floor and roof slabs is poured in one continuous operation and that the concrete is got well under the slab reinforcement. If possible, slab and beam should be poured in one continuous operation.

Note: To make certain that the bars are covered underneath some engineers require that a layer of concrete be spread over the slab centers and that the reinforcing net or bars be laid on top of it. Where wire mesh or expanded metal slab reinforcement is used working the concrete underneath it can be facilitated by lifting the mesh slightly by means of bars having a hook at one end.

Pouring Beams.—See that beams are poured in one continuous operation from bottom to top; that the concrete is worked closely around the reinforcement and into corners by thorough puddling; that the stone is worked back from the sides to permit the mortar to flow to the faces and give a smooth surface when set; that the space between the bottom of the mold and the bottom reinforcing bars is tightly filled. If possible beam and slab should be poured in one continuous operation.

Pouring T-Beams.—See that when beam and slab are designed to act together as a T-beam that both are poured in one operation.

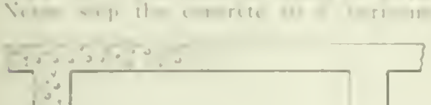
Pouring Columns.—See that columns are poured well ahead of the beams; that the pouring is a continuous operation from bottom to underside of supported beam or girder; that the concerte is freed from air bubbles and worked closely around the reinforcement and into corners by thorough puddling.

Puddling Columns.—See that the tampers used in concreting columns are long enough to go easily between the outside of the reinforcement and the inside of the form. See that the tampers are handled carefully so as not to strike and displace the reinforcement.

Places for Stopping Concreting.—See that concreting is stopped for the night or at other times at predetermined points and in a predetermined manner. If any unforeseen contingency compels concreting to be stopped at other points than those named as permissable use every precaution in bonding the fresh concrete to the old to secure a solid joint.

Note.—The general rules here given follow the prevailing practice of engineers. Personally, he believes that the greatest latitude can be safely allowed and that serious doubt exists as to the value of certain details of present practice in stopping off work. Recent tests indicate that a satisfactory joint can be secured between new concrete and old concrete at no great expenditure of money or time and with moderate skill of operation.

Stopping Slabs.—Stop the concrete in a vertical plane at right angles to the span either (1) at midspan or (2) over the center of the supporting beam or girder. Never stop the concrete on a horizontal plane at partly the height of the slab; never stop the concrete where the shear is great near the end of the span or under concentrated loads; never slope the joint, always make it vertical. (See Fig. 1.)



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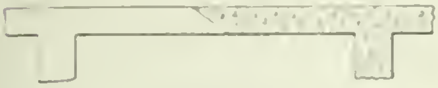

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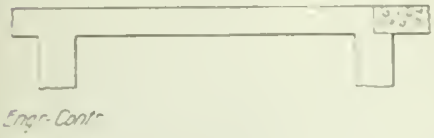

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Fig. 1—Methods of Stopping Off Concrete Girders.

Stopping Beams and Girders.—Stop the concrete in a vertical plane at right angles to the length of the beam either (1) at midspan or (2) over the center of the supporting column. Never stop the concrete on a horizontal plane at partly the height of the beam; never stop the concrete near the ends of beams where the shear is great; never slope the joint, always make it vertical. (See Fig. 2.)

Stopping Columns.—Stop column at the level of the bottom of the beam or girder which it supports and never at any other place unless compelled.

Stopping Walls.—Stop walls in vertical planes across the wall and locate stops, if practicable, where expansion joints are to come.

Joining New Concrete to Old.—See that every precaution is taken to secure good bond when joining fresh concrete to concrete that has already set. The surface of concrete which has hardened has a skin or coating to which fresh concrete will not adhere. This skin must be removed and the surface prepared for the new material. The following methods are employed:

(1) Scrub the old surface with wire brushes and thoroughly flush off all the material removed by the brushes. Wash the clean surface with neat cement grout and deposit the concrete against the grout coat while it is still wet. Vigorous tamping of the fresh concrete against the joint greatly improves the bond. In place of using a wire brush, the old surface may be picked all over.

(2) Treat the surface with an acid wash such as "Ransomite," which etches off the cement film. Wash all the acid off with plenty of pure water and apply the fresh concrete thoroughly tamped in place. The thorough removal of the [illegible] acid by washing with pure water is absolutely essential.

(3) "For connections made after a lapse of 24 hours or more, break back the surface concrete to firm material and clean the fresh surface with steam, air blast or forceful water stream so as to remove all fine loose material. Saturate well but not so that water stands on the surface or oozes from the material. Paint completely with neat cement grout mixed to the consistency of thin cream, just before new concrete is deposited, and see that the latter is of proper mixture, containing a proper proportion of mortar, which should be worked against the joint so as to be certain that no voids exist in its vicinity."—E. P. Goodrich.

(4) "For connections made after long intervals, so that the old cement has set hard and where the expense of rough pointing the whole surface is greater than is required because of the nature of the desired bond, use commercial muriatic acid, diluted with clear water, 1 to 5, or the commercial bonding powders, dissolved in clear water at the rate of 5 lb. of powder to 10 gals. of water. First wet the old concrete surface with so much water that a fresh wetting is not immediately absorbed. Remove any excess of moisture, and when the surface appears as if commencing to dry paint on the old surface three successive coats of acid, one after the other. Let this remain for about 30 minutes, after which carefully clean the surface of unspent acid, soluble salts, and fine material, with plenty of water, finally cleaning with a steam jet or air blast if obtainable. Just before the fresh concrete is to be deposited, and while the old material is still very damp, apply a thin coat of neat cement grout mixed to the consistency of thin cream, just before the new concrete is deposited, and see that the latter is of proper mixture, containing a proper proportion of mortar, which should be worked against the joint so as to be certain no voids exist in this vicinity."—E. P. Goodrich.

Concreting Connections.—See that particular care is exercised in concreting connections, such as the juncture of a column and a girder. The number of reinforcing rods at such points increases the liability of void spaces among and around the bars.

Coping Construction.—See that copings for walls are molded particularly straight and true to grade. The coping is the portion of the wall on which any variation from true alignment shows most objectionably, and its alignment should be watched with particular care. Where the body of the wall is for any reason slightly out of true, the defect can be largely concealed by capping it with a straight and true coping. The coping form should be [illegible] of the wall form proper.

Filling Tie Holes.—See that tie holes in the wall after withdrawing bolts used [illegible] are closed with mortar well tamped into the cavity and the holes troweled off flush with the wall face. The "pointing" must be carefully done. Keep the grease from the bolt remaining on the walls of the hole making it difficult for the mortar to stick.

Laying Electrical Conduits.—See that conduits, plumbing, electrical, etc., be not cut through or into the finished concrete in placing pipes, wires, etc. The proper holes, channels, etc., should be provided for in designing the work. If they are not provided for, nothing should be cut in the finished work without orders from the engineer.

Concreting Arches.—See that the arch ring is divided into sections of such size that the concreting of each section can be made a continuous operation. See that the concreting is made a continuous operation for each section.

Concreting in Transverse Sections.—See that the sections are concreted in pairs, corresponding sections on both sides of the crown being concreted simultaneously. If the concreting is begun at the haunches, see that the crown does not rise; at the crown, weight it down with a temporary load if necessary. The better practice is to concrete the crown sections first and work toward both skewbacks a pair of sections, one on each side, at a time. In arches of moderate span the sections are concreted in succession, but in long span arches alternate sections are concreted.

Concreting in Longitudinal Sections.—See that the concreting is begun simultaneously at both skewbacks and is continued uniformly and continuously to the crown.

Filling Over Arches.—See that the fill over arches is not put in too soon after concreting. Generally speaking two weeks should elapse after concreting is completed before any fill is placed over the arch, but conditions sometimes necessitate shortening this time. In such cases get definite instructions from the engineer.

Drainage.—See that inserted pipes, gutters, etc., intended for drainage are clear and unobstructed. Keep such channels plugged or protected from accidental choking or filling with concrete or other material until they are finally covered or capped.

Expansion Joints.—See that expansion joints are constructed exactly according to the engineer's plans.

Wetting Finished Work.—See that the concrete after the removal of the forms is not allowed to dry out too rapidly. When necessary keep the surface well wet by sprinkling, coverings of wet sand, burlap, etc. The persistence and amount of sprinkling required will depend on local conditions; the idea is to prevent the water needed for hardening the concrete from being evaporated, and the inspector's judgment must be exercised to determine when and what amount of sprinkling is necessary.

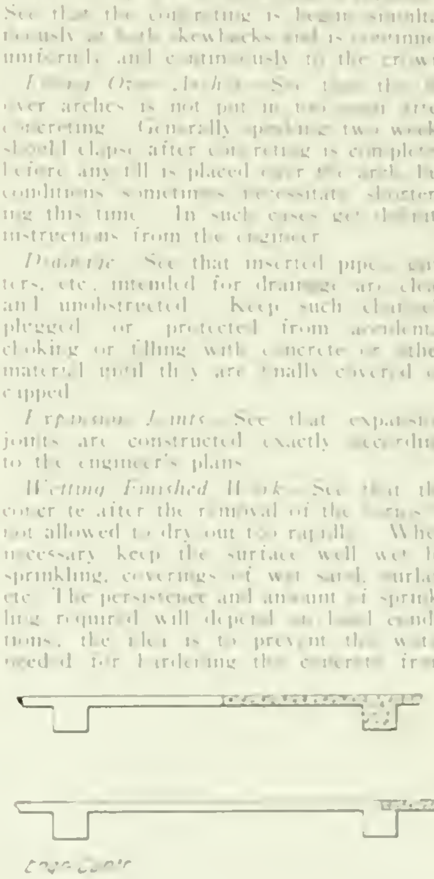
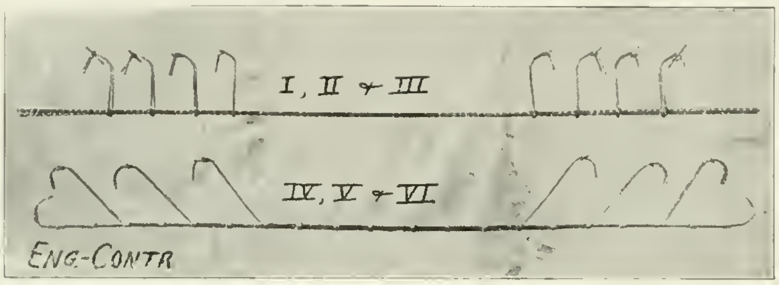


Fig. 2—Methods of Stopping Off Concrete Slabs.

Depositing Concrete Under Water.—See that the concrete, while being deposited, is kept as free as possible from wash, which will float off the fine cement from the mixture. See that the concrete is never allowed to drop loose through any considerable depth of water. The usual methods of depositing concrete under water are in bags, in closed buckets and through tremies.

Operating Tremie Pipes.—A tremie is a tube of wood or sheet metal long enough to reach from above the surface of the water to the bottom. It is operated by filling the tube with concrete and keeping it full by successive additions while allowing the concrete to flow gradually out at the bottom by raising the tube slightly to provide the necessary opening. See that the tremie is filled full before allowing any concrete to flow out at the bottom, and see that the tremie is kept full as long as concreting is in progress. See that the tremie is moved back and forth so as to deposit an even layer over the area to be covered. See that the movement of the tremie is not so rapid or that the tremie is not raised so quickly that all the concrete runs out and is "lost." Every time the tremie is charged anew it results in washed concrete until the tube is again full. A concrete that is mixed not quite wet enough to be plastic works best; if mixed very wet the chance of "losing" the charge is increased; if mixed too dry it is more liable to choke in the tube.



Reinforcing Frames for Test Beams.

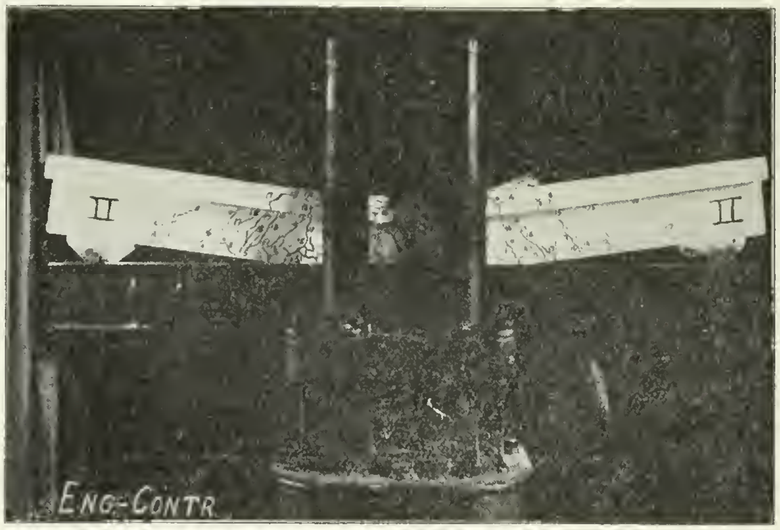
Depositing in Buckets.—Bottom dumping buckets with close covers are best. The idea is to keep the concrete closed away from the water until it is finally in place. See that the bucket is one which will dump close to the bottom, and that in dumping it is lowered as close to the bottom as it will go. See that the bucket is properly closed and latched, and that it is lowered vertically to the bottom as rapidly as practicable and is dumped without delay. See that successive bucketfuls are deposited so as to form as nearly as possible uniform layers over the area to be covered. Do not permit isolated piles of concrete to be placed.

Depositing in Bags.—Fill the mixed concrete into bags of gunnysack or other porous cloth and pack the bags closely into position. The bags keep the cement from free wash and yet when placed allow enough cement to ooze through the meshes to cement the whole mass together. Paper bags are sometimes used in place of cloth bags, the paper breaking open when soaked, so that the separate bagfuls are cemented into one mass. See that the bags are not filled too full to settle readily and closely together when piled in place. See that the bags are lowered rapidly through the water into place to reduce the time of wash. See that no delay occurs in the process of depositing which will permit concrete in place to become set before succeeding bagfuls are deposited. See that the delay between mixing the concrete and filling and depositing the bags is not long enough to permit the concrete to have set.

Broken Beam Showing Fractures.

Detecting Wash. — The existence of "washing" in concrete deposited under water is shown by the rising to the surface of a milky scum *(laitance.)* The presence or absence of laitance indicates quite clearly the presence or absence of "washing."

Protection From Currents.—Where there are currents a dangerous amount of washing may result after the concrete is in place. The only remedy in such cases is to deflect or break the current by shields or other means, and the means adopted must be determined for each case separately. The inspector should watch for trouble of this sort and promptly notify the engineer when it appears.



Test Beam in Testing Machine.

Rubble Concrete.—See that the rubble stones are solidly and completely imbedded in the concrete. When the rubble stones are irregular in shape a sloppy concrete must be used to get them thoroughly embedded; if the stones have flat beds they can be laid upon layers of dry concrete and have the vertical interstices filled with dry concrete by tamping. See that the rubble stones are well joggled or worked to a good bed with crow bars, and that vertical spaces are prodded and puddled to prevent arching and voids.

Composite Brick and Concrete Buildings.

One obstacle in the way of securing cheapness in constructing reinforced concrete buildings is the cost of the forms, which frequently cannot be used again. Mr. F. W. Dean, Mill Engineer and Architect, of Boston, has recently designed a number of buildings with brick walls and reinforced concrete floors and roofs, which remove this obstacle and overcome the objection frequently urged against the appearance of reinforced concrete buildings unless the owners are prepared to spend sufficient money to finish them up in an attractive manner. Unfortunately this is not often done in buildings of the manufacturing type. By the use of brick walls it is, however, possible to obtain the excellent appearance of brick work, and to do so without the use of forms. In the buildings designed by Mr. Dean the concrete girders and floor slabs are connected to the brick work without difficulty. The result is that the advantages of a reinforced concrete building are obtained, it is claimed, at less cost and without any special knowledge of concrete for the walls. Although the excellence of concrete walls is fully recognized, they nevertheless require a great deal of care in placing the concrete so that it touches the reinforcement everywhere and fills all of the spaces.

Results of Tests of Deflection of Reinforced Concrete T-Beams.*

BY A. B. WHITE.†

Figures 1 and 2 show the details of six reinforced concrete tee beams which were tested, when 60 days old, by concentrated loading at the one-third points in an Olsen 100,000-lb. universal testing machine. The purpose of the tests was to determine the relative efficiency of two different types of reinforcement. As shown by the details, the reinforcement in three of the beams, designated as Nos. I, II and III, consisted of two ½-in. square corrugated bars, with vertical stirrups between the loading points and the supports, while the reinforcing member in the other three beams, Nos. IV, V and VI, was made up by assembling four flat steel bars 1 x ⅛ in. in section, and bending up their ends to form diagonal stirrups. The latter form of reinforcement is a suggestion which has been but recently patented (Apr. 13, 1909) by Mr. E. White of New York City, its object being economy in steel, as shown by the itemized weights, together with the advantages secured by having diagonal stirrups integral with the tensile reinforcement.

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*These tests were made by Mr. White at Swarthmore College and form a portion of the author's graduation thesis.

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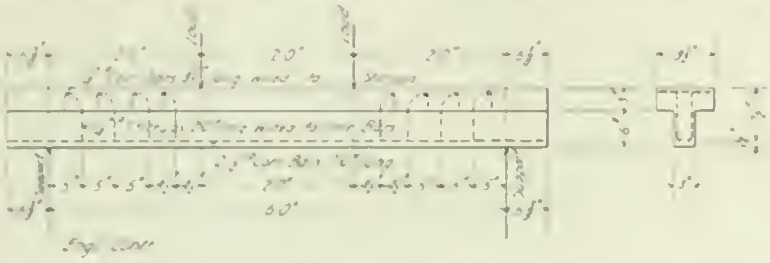

Fig. 1—Details of Beams I, II and III.

MATERIAL FOR ONE FRAME

	Length	Weight
Bar 1"x⅛"	4' 10"	2.06
Bar 1"x⅛"	6' 2"	2.62
Bar 1"x⅛"	7' 6"	6.28
Strand Clinton Wire No. 10	7' 6"	.27
Trans. Clinton Wire No. 8	1' 0"	1.75
¼" Corr. Bars	[illegible] 8½"	1.02
Weight of one frame complete		14.00

The beams were made of 1:2:4 stone concrete, 6-in. cubes showing at 60 days the remarkably high crushing strength of from 3,000 to 4,000 lbs. per sq. in. The corrugated steel bars showed in tension test a yield point of 41,600 lbs. per sq. in., while the flat steel bars showed a yield point of 45,100 lbs. per sq. in.

The behavior of the beams in deflection is shown by Fig. 3 (p. 374). It will be observed that the deflection curves are approximately parallel but that the yield point in deflection of beams Nos. IV, V and VI is considerably higher than that of Nos. I, II and III. This is partly accounted for by the higher yield point of the flat steel bars, and partly by the fact that considerable diagonal tension failure was noticed between the vertical stirrups in beams Nos. I, II and III, whereas in the other three beams the cracks which developed were nearly all vertical, and hence less destructive to the stiffness of the beam. The cracks in the webs of the beams were first observed at loads of about 5000 lbs., and it will be noticed that this is slightly above the point at which the curves become straight lines and the slope less steep, showing that below this point the tensile strength of the concrete is of considerable importance.

In Table I are given data obtained by averaging the observations made on the six beams within the elastic limit. The computed deflections there given were obtained as follows, the method of obtaining the equivalent moment of inertia of the concrete beam being that proposed by Mr. F. White in "Engineering Record," Nov. 9, 1907. (See ENGINEERING-CONTRACTING, Apr. 14, 1909, p. 287.) The theoretical position of the neutral axis was determined by the usual straight line relation, assuming $n = 15$ and neglecting tension in the concrete.

TABLE I.

Ref. No.	Applied Load in Lbs.	Bending Moment in Inch Lbs. From* Applied Load	Bending Moment in Inch Lbs. From Ext. of Steel	Proportionate Depth, K, of Neutral Axis.	Deflection in Inches Observed	Deflection in Inches Computed
1	1,000	11,200	2,030	62	.004	.011
2	2,000	22,500	4,960	62	.008	.021
3	3,000	33,700	12,920	50	.017	.032
4	4,000	45,000	23,300	45	.029	.042
5	5,000	56,200	37,700	40	.045	.053
6	6,000	67,500	49,000	39	.065	.064
7	7,000	78,700	62,000	37	.082	.074
8	8,000	90,000	74,300	37	.101	.085
9	9,000	101,000	86,900	36	.121	.095
10	10,000	112,000	101,000	36	.141	.106
11	11,000	124,000	112,000	35	.160	.117
12	12,000	135,000	121,000	35	.180	.127
13	13,000	146,000	134,000	34	.201	.138

*Corrected for friction of loading apparatus.

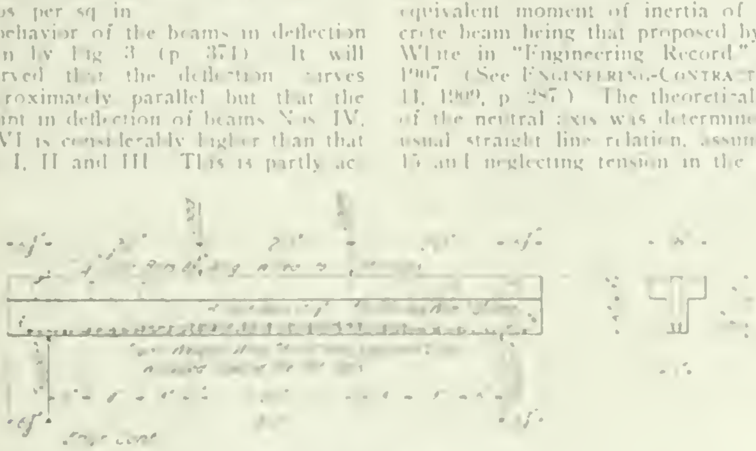

Fig. 2—Details of Beams IV, V and VI.

MATERIAL FOR ONE FRAME.

	Length	Weight
½" Corr. Bars	[illegible]	[illegible]
¼" Corr. Bars	[illegible]	[illegible]
¼" Stirrups	[illegible]	[illegible]
Iron wire No. 18 to assemble frame		[illegible]
Weight of one frame complete		[illegible]

The moment of inertia of the section was taken as equal to double the moment of inertia of the cross-section of steel reinforcement about the neutral axis (thus again neglecting tension in the concrete). The deflection of the beam due to bending was then obtained by use of the general equation of the elastic curve for a beam of constant moment of inertia I and modulus of elasticity E, as given in works on the resistance of materials, namely,

$$E\,I\,\frac{\delta^2 y}{\delta x^2} = M$$

where M = the bending moment at any section. This equation was integrated twice for the given conditions of loading, and after introducing values for E and I, namely E_s, the modulus of elasticity of the steel = 28,000,000, and I_s the equivalent moment of inertia of the steel, as explained above, an expression for the deflection at the middle of the beam due to bending was obtained in terms of the total applied load, P.

On account of the heavy shearing stresses in the end portions of these beams, it was thought advisable to include in the computed values of deflection the part due to vertical shear, which in this case was found to be about 7 per cent of the total.

This was obtained by one integration of the general equation $\frac{\delta y}{\delta x} = \frac{V}{aF}$ where V = vertical shear ($= \frac{1}{2}P$ in this case), a = area of cross-section of beam ($= b' \times d$),

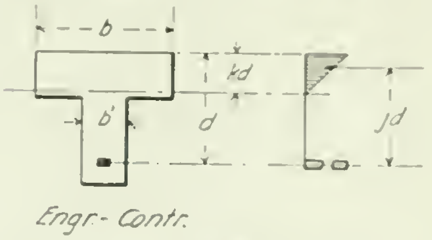

Fig. 4.

E_s = Modulus of elasticity of steel in tension.
E_c = Modulus of elasticity of concrete in compression.
$n = \frac{E_s}{E_c}$
A = Area of cross-section of steel reinforcement.
$p = \frac{A}{bd}$
I_s = Σ Moment of inertia of steel about neutral axis.
I = Σ Moment of inertia of concrete below neutral axis about neutral axis.

and F = shearing modulus of elasticity of the beam, assumed for this purpose as 800,000, or ⅓ the modulus of elasticity of concrete in compression.

It will be observed in the table that the computed value of deflection agrees with the observed value at one point only, namely for a load of 6000 lbs., which would be the ordinary working load for these beams. Below this load the observed values are less than the computed ones and above it are greater. The former discrepancy is to be explained by the tensile strength of the concrete which was unimpaired up to this point, and which was not taken account of in the computation. The discrepancy for the higher loads is sufficiently accounted for by the failure in the webs of the beams between the loading points and the supports after cracks began to develop.

It should be noted that the theoretical method of obtaining deflection described above should really be modified for the type of reinforcement used in beams Nos. IV, V and VI, in which the cross-section area of the steel diminishes from the middle of the span to the supports and which would consequently be expected to cause greater deflection. The fact that the deflection curves of these beams are practically parallel to those of the first three would seem to indicate that the diagonal stirrups were better adapted, under the given conditions, to resist failure in the web and consequently to preserve the stiffness of the beam than were the vertical stirrups.

For the lower loads, the theoretical deflections will agree more closely with the observed values if the tensile strength of the concrete be considered in finding the deflection due to bending. This may be done by substituting E_c and $I_c + n I_s$ in the equation of the elastic curve instead of E_s and I_s, as explained above, symbols being defined in Fig. 4. For practical purposes, however, the method first outlined, namely considering the moment of inertia of the steel only and neglecting tension in the concrete should give quite closely the deflection to be expected in concrete beams under working loads or higher test loads up to the elastic limit of the beam. The consideration of the deflection due to vertical shear will rarely be necessary in cases arising in practice.

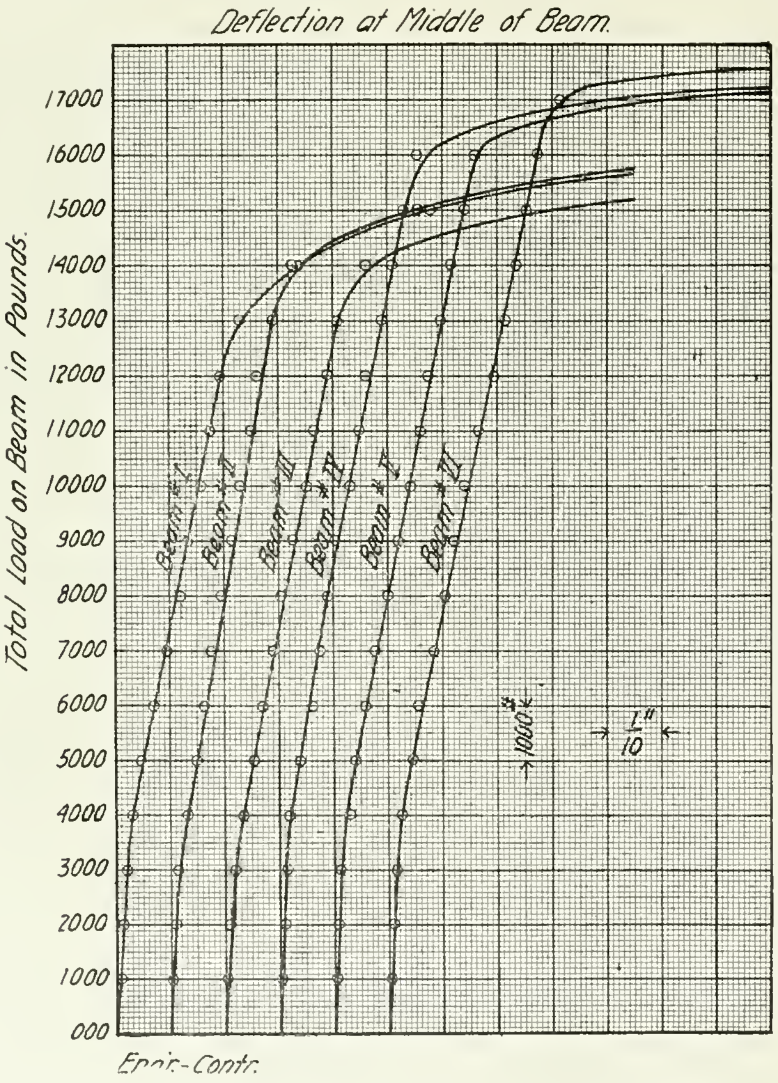

Fig. 3—Diagram Showing Deflection of Concrete Beams.

The grand total of excavation on the Isthmian Canal for the month of March was 4,062,632 cu. yds., of which 2,339,033 cu. yds. were removed by steam shovels 1,695,342 cu. yds. by dredges and 28,257 cu. yds. by hand and scraper.

Earth and Rock Section

Note: This Section is devoted to methods and costs of excavating earth and rock and building embankments. It will cover the grading of roads and railroads, diking and canal work, dredging, building reservoirs and earth dams, sewer and water pipe trenching, quarrying, etc.

Some Methods and Costs of Revetment and Dam Work, Rock Chiseling and Submarine Drilling and of Cofferdam Work; Upper Mississippi River Improvement.

The works constructed in the upper Mississippi River afford excellent illustrations of the successful solution of many of the problems that arise in the improvement of non-tidal rivers. The obstacles at the Des Moines Rapids have been surmounted by a lateral canal. At the Rock Island Rapids a channel has been excavated through the rock composing the bed of the river and the slopes modified by submerged dams and wing dams, as effectively as in the celebrated improvement of the Iron Gate on the Danube. The stretch of river from St. Paul to Lake Pepin is an example of as successful a regulation of a river by wing dams and bank revetments as can be found on any river in Europe. Levees have been constructed which protect from overflow 220,000 acres of alluvial bottom lands, and harbors of refuge from ice and storms have been built.

The work on the Upper Mississippi River described in this paper extends from the Omaha bridge at St. Paul, Minn., to the mouth of the Missouri River a distance of about 658 miles. At St. Paul the river drains an area of about 32,000 square miles and has an extreme low water discharge during the season of navigation of about 2,000 cu. ft. per second. The extreme flood height recorded, that of 1850, is 19.7 ft. above datum—the low water of 1864, and 20.0 ft. above the low water of 1894, the lowest recorded stage that has occurred when the river was not frozen over. The discharge of the river has been measured at a gage height of 17.5 ft. and found to be about 85,000 cu. ft. per second.

BANK REVETMENT.

The works of improvement, consisting of bank revetment, wing dams, closing dams and longitudinal dikes, are generally constructed of brush and rock. The bank revetment consists, below the water surface at the time of construction, of a mattress of brush fascines sunk in place by rip rap rock; above low water line, of a rip rap of 6 to 12 ins. of rock. The width of brush mattresses varies from 20 to 60 ft., being affected by the stage of river at time of construction, and the depth of water. The fascines are preferably made of willow brush, which is found in large quantities on the islands and sand bars in the river, but where there is a local scarcity of willows, the use of other varieties of wood sufficiently straight to be bound into fascines has been allowed. Recent specifications require that fascines shall be made of live brush sufficiently trimmed and choked to form a compact mass 20 ft. long and from 12 to 15 ins. in diameter, and tied with bands of lath yarn or wire not more than 4 ft. apart. When made into mats they are closely packed and secured at distances of 8 to 12 ft. by pairs of binding poles joined by ties of lath yarn or wire about 2 ft. apart. The fascines are laid with their butts pointed down stream. The early practice was to lay the fascines at right angles to the shore line, butts to the bank, but in this position on steep banks there was found a tendency of the stone covering to slip.

The mattresses are constructed on small flats having inclined ways upon them, which are locally known as "grasshoppers." The grasshopper (Fig. 1) is a small boat, the hull of which is about 2 ft. deep, 14 to 22 ft. in width, and 32 to 40 ft. in length. On this hull are placed ways or skids running fore and aft, usually 4 or 5 pieces of scantling rounded and smoothed on the upper side. They are given an angle of about 30° with the water surface, to facilitate launching the mat, and extend over the forward end nearly to the water surface. When a length of mat equal to the length of the ways has been constructed, the grasshopper is dropped down the river a distance of about 20 ft, a corresponding length of the mattress sliding into the water, and another row of fascines is then added, lapping the preceding row from 8 to 10 ft. In this manner a continuous mattress is constructed along the bank to be protected. It has been found advisable to employ small binding poles, to give greater flexibility to the mat. In some portions of the river three or four good sized willow brush are substituted for the binding pole, with advantageous results. The necessity of flexibility in the mat is not only to prevent rupture while sinking, but it is found that as soon as the mat is in place the river currents produce a scour at the toe of the mat, and unless it is sufficiently flexible to conform to this scour, it is undermined and slips farther into the river, producing a break in the revetment at the water surface.

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*Condensed from a paper by C. McD. Townsend, Lieutenant Colonel, Corps of Engineers, U. S. A., presented to the Western Society of Engineers, Nov. 4, 1908.

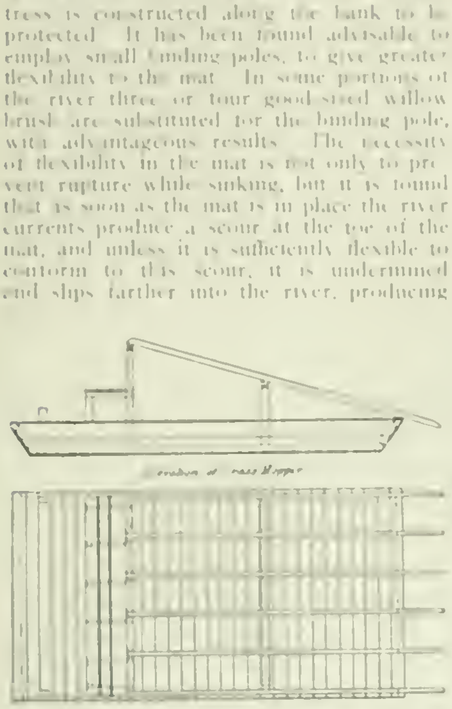

Fig. 1—"Grasshopper" for Making Mattresses.

The upper bank is graded to a slope of from 1 on 1½ to 1 on 3 before the rip rap is placed. In the upper portions of the river, where the banks are low, the work is done by manual labor. In the vicinity of the mouth of the Missouri, where the banks are higher and more sandy, economic results have been obtained by the use of a drag scraper operated by the steam engine on a pile driver. It has been the practice on certain portions of the river to sink the mattress one season and allow the river itself to grade the upper bank during the next flood and complete the work another season. This method of procedure is economical, provided the completion of the work be not too long delayed.

Wing dams (Fig. 2) are constructed for the purpose of contracting the width of the river at low stages. It was originally proposed to construct the dams in accordance with the practice on German rivers as described by Schlichting, giving them an inclination up stream, in straight reaches of 105°-110°, on concave banks, 100°-105°, and on convex banks, 90°-100°, and so laying them that their axes intersect in the middle of the channel. They were to be spaced at 5/7 of channel width in straight reaches, one half the channel width on concave banks, and [illegible] width of the channel. While in general this plan has been adhered to, there have been numerous exceptions, particularly in the spacing of the dams, due principally to economic considerations. The heights to which the dams have been constructed are also variable. The present practice is to build them to a grade 1 ft above low water in the upper portions of river and [illegible] ft above water below the Des Moines Rapids. In their construction mattresses comprising a single layer of brush fascines bound with three sets of binding poles are laid along the entire length of the dam to prevent scour during the process of construction and to serve as an apron to receive the flow over the dam. This is covered with a layer of rip rap rock about 6 ins. thick on the upper side and 1 ft to 18 ins on the lower side. A second mat is sunk on this rip rap from 10 to 15 ft further up stream and covered with stone. Additional mats are similarly placed and covered until the required grade is attained, each mat being placed 2 ft further up stream than the one immediately below it. In filling deep holes the use of multiple mats is permitted, i. e., mats composed of several layers of fascines. To prevent the erosion of the bank, it is revetted 25 to 50 ft. above and about 50 to 75 ft below the point where the dam abuts against it.

In dam construction a building boat is required. The building boat (Fig. 3) is held in position by lines extending to anchors, anchor mats, or piles, previously put in position, and a barge of brush placed along its upper side. A barge of stone is held about 20 ft. below by lines extending to it, and between the building boat and rock barge is placed the grasshopper on which the mat is constructed.

The mats for dams are constructed with the fascines laid across the grasshopper, butts down stream. They are usually bound with three sets of binding poles securely tied with lath yarn or wire, usually at every third fascine. The length of the mat varies with the swiftness of the current and depth of water, but rarely exceeds 100 ft. Three quarter inch lines are attached to the binding poles over the tips about 10 ft apart, and to the binding poles over the butts about 20 ft. After the mat is launched these lines are fastened on kevels on the building boat. Care is required in sinking the mat to prevent the river currents from turning it over and dumping the load of rock. An excess of rock is placed on the upstream side of the mat, and the lines connecting it to the building boat are gradually eased off. In shoal water the upstream edge of the mat is sunk to the bed of the river before the lines running from the butts to the building barge are loosened. After the mat is sunk, the rock is uniformly distributed over it, and the lines used in sinking it are then removed, having been originally attached with a turn to facilitate their removal.

On the lower sections of the river the mat is constructed from tilting ways on the building barge instead of from a grasshopper as above described. The building boat is 165 ft × 26 ft × 4 ft, and is equipped with two steam capstans and a set of 100 ft tilting ways. There are also hand capstans for handling by hand (if necessary) the anchor lines and the lines extending to the stone barge. The hand capstans are the No. 1 Providence, and are convenient [illegible] when the lines are manipulated by steam. The steam capstans are of the single cylinder steamboat type. The tilting ways are made of 3 in. × 5 in. × 18 ft [illegible] timbers. These timbers are set on edge about 8 ft apart and securely fastened together by a fire [illegible] and [illegible] stringer on the outboard side. [illegible] they are set in a [illegible] 1 ft high, to which they are [illegible] by a [illegible] strap hinge. To each alternate way is attached a 1½ in. pine timber that extends through a hole in the deck to near the bottom of the boat when the ways are horizontal. A wire rope runs from the lower end of each of these timbers to a pulley on the deck above it, and is joined to a wire rope extending along the back of the ways to a pair of triple blocks, which are connected with the drum of one of the steam capstans. After the mat has been constructed, by winding on this capstan the inboard ends of the ways are raised and the mat launched.

The closing dams, which are employed to close chutes and side channels, are constructed similarly to wing dams, but usually contain more rock and the bank revetment extends a greater distance both above and below them. In long chutes, at low stages a head of water exceeding 4 ft may exist on the dam; in such cases breaks have been not infrequent, and the experiment has recently been made of multiplying the number of dams in the chute so as to diminish the head on each and to increase the tendency to deposit sediment in the chute.

Longitudinal dikes are similar in construction to wing dams, but, as their name indicates, instead of being built approximately at right angles to the current, they extend approximately parallel to it.

During the first years of the improvement, pile and brush dams (Fig. 4) were built quite extensively in the river above Hastings. In constructing these dams, an apron was laid in the usual manner and piles were driven through it on the line of the dam. The distance between piles was about 4 ft. They were connected by a stringer at a height of about 3 ft above low water. Against this stringer brush fascines were laid side by side with their tips up stream and their butts extending over the stringer about 1 ft and bound to it with binding poles and wire. A small amount of rock was then thrown on the tips. Due to the small quantity of sediment in the upper river these dams have not been as successful as similar ones in the river below St Louis have been. They were cheaply constructed, but after a few years they became so dilapidated that it was necessary to convert them into the ordinary brush and rock dam.

Where it has been necessary to dredge through gravel bars, the material removed has been frequently employed as a foundation for dams and topped with regular courses of brush and rock. The ferry dike opposite Hannibal was built entirely of gravel, dumped at a 7 ft stage, and has required no repairs since its construction in 1883. A number of sand dams have been built above Lake Pepin with an hydraulic dredge, which deposits the body of the dam in such a shape that a single course of brush and rock completes it. Their cost is about one-half that of the ordinary brush and rock dam. They have usually been put in as intermediate dams of a series and in such a location as not to be as exposed as the ordinary type.

The proportion of brush to stone employed in constructing the different works has varied. The present practice is [illegible] bank revetment (see Fig. 5), about 1 to 1 [illegible] closing dams 1 cu ft rock to 1½ cu ft brush, for wing dams 1 cu ft rock to 2 cu ft brush. A number of dams have been constructed

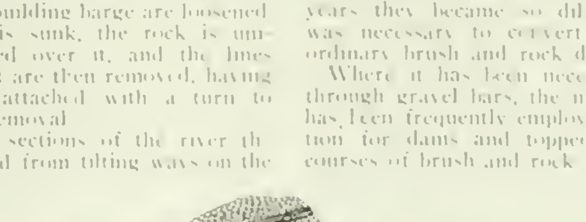

Fig. 2—Section of Wing Dam.

with the ratio of rock to brush 1 to 4. The repairs to these dams have been greater than to those containing a larger percentage of rock.

At the close of the calendar year 1905, there had been built 231.6 miles of dams and 188.6 miles of shore protection. The dams contained 3,630,234 cu. yds. of rock and 5,310,742 cu. yds. of brush. The bank revetment contained 1,725,685 cu. yds. of rock and 1,549,525 cu. yds. of brush, an average of 1.73 cu. yds. of rock to 1.55 of brush per linear foot. During the fiscal year ending June 30, 1906, 182,735 cu. yds. of rock and 275,825 cu. yds. of brush were expended on wing dams and revetments.

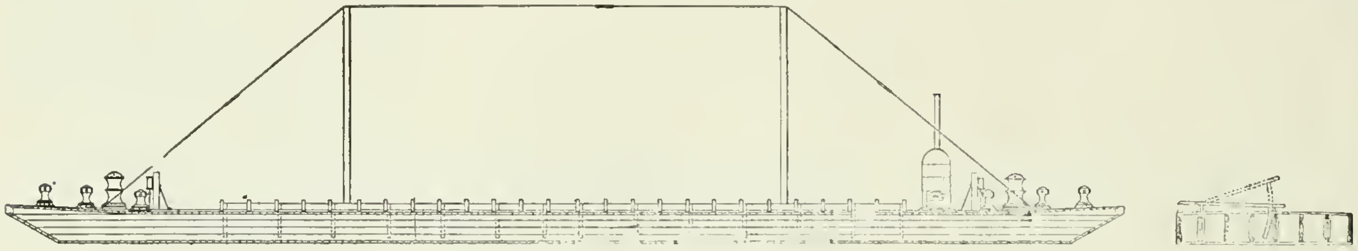

Fig. 3—Dam Building Boat.

ROCK EXCAVATION.

In 1888, a Board of Engineer officers was convened to prepare and submit a project for the further improvement of Rock Island Rapids, either by widening or deepening the present channel through the rapids or by a canal around the rapids on the Illinois side of the river.

The Board submitted estimates for two methods of further improvement: A canal around the rapids on the Illinois side of the river, and widening and deepening the present channel of the river at the rapids. The estimate for a canal in the bed of the Mississippi River, 200 to 500 ft. wide and having a depth at low water increasing from 6 ft. at the head to about 12 ft. at the foot, was $3,704,722.67. To enlarge the river channel to 400 ft. width and 4½ ft. depth below water, the cost is estimated at $1,258,866. To enlarge the river channel to 400 ft. width and 6 ft. in depth below low water, $3,491,010.

The improvements recommended by this Board were:

(1) Guide piers, with lights and day beacons, of sufficient strength to resist the action of ice and of sufficient number and so located that while being of no obstruction to navigation they will serve as reliable guides to pilots in making the passage at night.

(2) To excavate and remove rock at various points, in order to widen and straighten the channel at crooked portions of the rapids, giving longer straight reaches, and to deepen it at some places, as at Duck Creek Chain. Such excavation will include the several small patches of rock lying on or near the channel.

(3) A system of dams is proposed for slightly raising the water surface at low stages and equalizing to a certain extent the slopes above and below Hampton, especially the current through Campbells Chain, with a view of preventing the deposit of sand in the channel. The estimate of cost:

Rock excavation, 33,140 cu. yds., at $6	$198,840
Dam construction, 39,500 cu. yds., at $1.50	59,250
24 piers, at $1,500	36,000
Dredging	5,000
Contingencies	39,909
Total	$328,999

Work was begun under this project and was practically completed in 1906, but with material modifications. The dams constructed at Campbells Chain not only scoured out the sand in the channel, but also materially increased the depth of water and diminished the slope on the three chains above. At Duck Creek Chain a similar set of dams was introduced, which rendered rock excavation unnecessary in the channel at this locality, and reduced the velocity of the current on the Winnebago Chain above and to some extent on Campbells Chain. The slope at Duck Creek Chain then became excessive and was lengthened by constructing in the pool below a series of submerged dams extending to within 6 ft. of the low water surface. Prior to 1876 the work was done by contract; since that date by the employment of government plant and day labor.

The methods of rock excavation employed were:

1. By cofferdam, drilling by hand, and use of common blasting powder.
2. By chisel and dredge.
3. By drillboat, submarine blasting with dynamite, and removal of rock by dredge.

(1) *By Cofferdam.*—The method of constructing the dams was as follows: A breakwater was first constructed about ten feet above the proposed dam, to break the force of the current, and afford comparatively still water on the down stream side. It consisted of a series of cribs, generally about 10x10 ft., spaced about 16 ft. apart in the clear, and sunk by being filled with stone. Strong timbers were then laid from one crib to another, and a sheathing of plank was placed along the connecting timbers with one end resting on the timbers and spiked to them, and the other end resting on the bottom, the plank being inclined at an angle of about 45° with the water's surface.

Timber work for an upper corner of the dam was framed and sunk in its proper place with two pairs of lower wall timbers, one pair extending down stream and the other across, attached by means of tie rods to the frame work, the timbers of each pair being secured to each other by the middle tie rods, the outer ends being held up to the surface by a float. Small rafts were moved along on each side of the line of the cofferdam, to afford sufficient space for working. Another pair of lower wall timbers (or stringers) was then fastened by means of tie rods to the floating ends already in, and secured to one another as before. A pair of upper timbers located above the surface of the water was then attached to the fixed part of the dam. Sinking planks were spiked to the pair of lower timbers nearest to the fixed part of the dam at right angles to their length and projecting below them as much as was found by sounding necessary to keep the lower wall timbers as nearly horizontal as possible. This pair of timbers was now sunk until the ends of the sinking plank rested on the bottom. The upper timbers were raised a few inches above the surface of the water and spiked to the sinking plank, the frame thus made being weighted to keep the timbers in place. The side planks which were chamferred to a thin edge at the lower extremities, were then driven into close contact with the bottom and spiked to the top timbers, care being taken to keep them in contact with the lower timbers. The space was then ready for filling. The puddling or filling was taken from the river bed and shore, and consisted of clay mixed with gravel, which material was always found at moderate distances from the work.

After the filling became compact the water was slowly pumped out of the cofferdam and the space inclosed was ready for the work of excavation. No special tamping or packing was employed—the material being such as to readily settle and spread into the cavities. The size of timber and thickness of plank varied according to depth of water and consequent height of dam and pressure. In deep water three rows of stringers were sometimes used as affording greater stability, and the dams were often braced from the inside at threatened points. The thickness of the filling of the upper and lower ends was about 10 ft., they being generally in deeper water than the sides, which had ordinarily an inside thickness of about 8 ft.

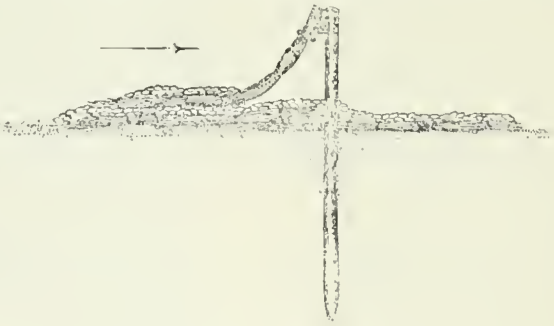

Fig. 4.—Pile and Brush Dam.

Although the dams used in the improvement of Rock Island Rapids were in general built in comparatively shallow water (from 6 to 14 ft. in depth), Sycamore dam, which was the largest built, attained at some places a height of 26 ft. above the bed of the river.

The quarrying was performed by the use of the ordinary hand drill and blasting powder. The drills used varied from 1½ to 2½ ins. in diameter, and the depth of holes from 1 to 4 ft. To avoid the effect of moisture in the rock and to form a water-tight magazine, the holes were sponged out and partially filled with a stiff pliable clay. The drill was then forced into this clay, pressing it against the sides and making a water-tight lining. The proportion of rock excavated to powder used was 7-13 cu. yds. to 1 lb. of powder.

When the excavation was finished and inclosure cleaned of broken rock, etc., the water was let in and the dams and cribs removed by dredge. Cofferdams were frequently damaged and sometimes broken in by passing steamers and rafts. Table I shows the cofferdam work done at the Rock Island Rapids:

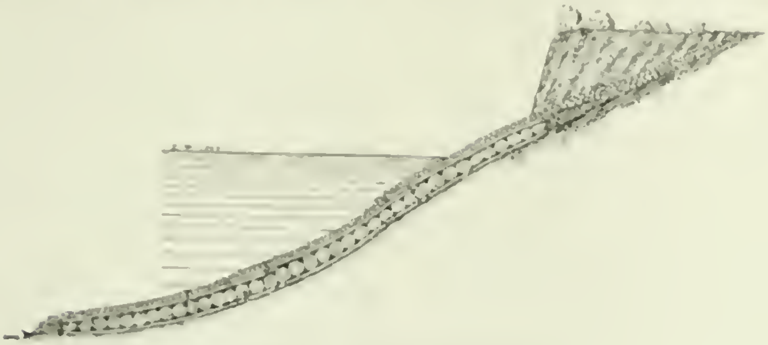

Fig. 5—Bank Revetment.

Table I—Dimensions of Coffer-dams Constructed During Improvement of Rock Island Rapids, with Location and Quantity of Rock Excavated.

	Development Lin. ft.	Area Acres	Amt. of rock excavated cu. yds.
Duck Creek	1,310	2.29	5,183.80
Moline	2,617	6.03	16,958.41
Sycamore	5,171	42.91	17,376.66
Campbells	7,760	43.07	7,832.86
Smiths	2,200	4.84	5,798.87
Upper	1,710	2.26	3,697.70
Between Smiths and Sycamore No. 1	960		807.10
Between Smiths and Sycamore No. 2	840		817.20
Crab Island No. 1	1,100		1,077.10
Crab Island No. 2	1,020		1,446.9[illegible]
Lower No. 1	1,707	2.27	2,649.6[illegible]
Lower No. 2	1,480	2.81	2,710.2[illegible]
Total excavated by coffer-dams			67,781.8[illegible]

(2) *By Chisel and Dredge.*—The chisel was used for breaking rock that was found in patches or in boulders too small in area to justify the construction of an inclosing cofferdam. The use of the chisel boat dates back to 1855, when Major J. G. Floyd, United States Agent, used on the Des Moines Rapids a stick of oak timber 12 ft. long and about 12 ins. square, with bars of railroad iron let into the side as ribbands to work in the uprights prepared for the purpose and set up on one end of the boat. The timber was shod with a conical shoe of wrought iron weighing about 300 lbs. and having a pyramidal point of steel. The chisels were afterwards made of wrought iron 9 ft. long with a steel point. The upper end worked loosely in a "head" from which the chisel was suspended and was so arranged as to allow the chisel to glance from the rock without injury to the boat. Its weight was about 3½ tons. The steel point was detachable, so that when it became dull it could be removed and another substituted. The "head" was made of tough elm or bass wood and raw hide bolted together so as to bring the raw hide at the neck of the chisel, where there was the greatest wear. The chisel was operated by machinery and leads similar to those of a pile driver, which were placed on a suitable flatboat. The fall was about 7 ft. The boat was maneuvered by anchors, lines and windlasses so as to reach the point desired, the chisel working from the down stream end of the boat. On the Rock Island Rapids the chisel was reported to be very efficacious where the cutting was small (18 ins. or less), while on the Des Moines Rapids it was not satisfactory. Table II shows the quantities of rock removed by chiseling and dredging.

(3) *By Drillboat Submarine Blasting and Dredge.*—In 1875, at St. Louis Chain, tripods were placed on the rock to be excavated, and from platforms built on the tripods holes were drilled by hand, the rock blasted, and the broken rock raised by a derrick boat. About 305 cu. yds. of rock were removed by this means. While this method can be employed advantageously for small patches of rock, it has been found with the development of the steamdrill that it was more economical to mount the drill on a barge, which could be moved readily from place to place and since 1875 the work of rock removal has been performed on the Rock Island Rapids by means of the drillboat. The latest form of drillboat employed consists of a barge 84 ft. long by 18 ft. wide, on one side of which are mounted two steamdrills. A boiler room and blacksmith shop occupy the middle of the boat, and the boat is held in position by spuds. Maneuvering lines are also attached for moving the boat out of danger during blasting operations.

Table II—Quantities of Rock Removed by Chisel and Dredge in the Improvement of Rock Island Rapids.

	Rock excavated cu. yds.	
Duck Creek	5,917.92	Patches above and below the coffer-dam and also between Duck Creek and Moline.
Moline	2,741.78	Patches above and below coffer-dam.
Sycamore	247.18	Strip of rock on which lower end of coffer-dam rested.
Campbells	1,154.12	Patches above and below the coffer-dam.
Smiths	842.59	Patches above coffer-dam.
Upper	491.39	At head of chain.
Between Smiths and Sycamore	1,694.71	Scattering patches of small area.
Crab Island	4[illegible].00	Patches below coffer-dam.
Saint Louis	2,7[illegible].29	Nearly all work at this chain done by chisel.
Winnebago	2,114.90	All work at this chain was done by chisel.
Lower	70[illegible]	Strips on which the coffer-dam rested.
Total	[illegible]	

The usual method of procedure is as follows: The drillboat is first spudded in position, and holes 3 ins. in diameter are drilled 4 ft. apart into the bed rock and are sunk to a depth of 3 ft. below grade to avoid reblasting. The distance between rows of drill holes is also usually 4 ft. The holes are then freed from debris by flushing them out with water discharged through a hose with a long nozzle. The charges of dynamite are then pushed to the bottom of the holes through a long tube having a slot in the side to accommodate the fuse wires, and a wad of old junk is rammed down on top of each load to tighten and hold it securely in place. The number of loaded holes on a line, ranging from 1 to 17, having been finally connected by splicing the wires to form a circuit, the drillboat is moved away to a distance of 50 to 75 ft., and the blast is then fired with a battery. The average amount of dynamite used per solid cubic yard of rock blasted is 2.29 lbs., and the average amount of solid rock blasted per day of 16 hours by one drillboat is 30.86 cu. yds. There is great variation, however, due to depth of drilling, quality of material, and the amount of sand and gravel found overlying the reefs. In deep ledge rock which breaks up so as to permit holes to be drilled 8 ft. apart, an output of 72 cu. yds. of solid rock per day of 16 hours was obtained, with an expenditure of 1.17 lbs. of dynamite per cubic yard.

Table III gives the quantity of dynamite generally used for holes of various depths and in different kinds of material.

Table III.—Showing Amount of Charge for Holes of Different Depths.

Depth of hole	3ft.	4ft.	5ft.	6ft.	7ft.	8ft.
Dynamite in hard rock, lbs.	2½	3¼	4	4¾	5½	6¼
Dynamite in rock medium to soft, lbs.	[illegible]	2¾	3¼	3¾	4½	5¼

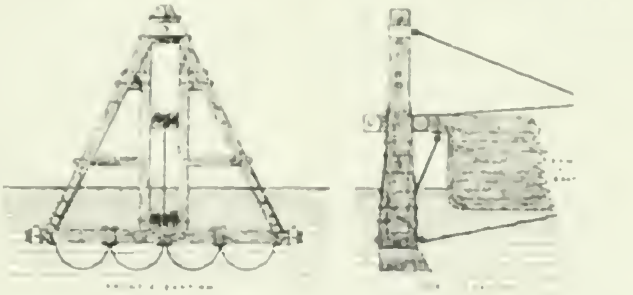

Fig. 6—Scraper for Lowering Bars.

The dams on the rapids have usually been built from the rock excavated from the neighboring chains. Submerged dams are given an elevation of 6 ft. below low water, the ordinary wing dams 1½ ft. above low water. The longitudinal dike extending above Benhams Island was built by the Ordnance Department, U. S. Army, to increase the head on a dam in Sylvan Water that has been constructed to supply power to the Rock Island Arsenal. Table IV shows the cost of rock excavation by various methods at the Rock Island Rapids work.

Table IV.—Cost of Rock Excavation, Rock Island Rapids.

Year.	Locality.	Removed from (solid cu. yds.)	Cost per cu. yds.	Method.
1868	R. I. Rapids	21,253	$10.00	
1869	R. I. Rapids	12,671	13.00	
1870	R. I. Rapids	1,172	13.00	
1870	R. I. Rapids	7,833	11.50	
1872	R. I. Rapids	5,599	10.35	Contract; coffer-dams, steam and hand-drills, powder.
1872	R. I. Rapids	1,622	11.00	
1872	R. I. Rapids	3,698	14.00	
1875	R. I. Rapids	2,650	12.00	
1876	R. I. Rapids	2,341	12.00	
1876	R. I. Rapids	305	11.13	Hired labor; hand-drills, dredge, powder.
1879	R. I. Rapids	682	10.78	Hired labor; steam-drill boat, dredge, dynamite.
1886	R. I. Rapids	445	7.00	Contract; chisel and dredge.
1887	R. I. Rapids	1,343	8.47	Contract; chisel and dredge.
1889	R. I. Rapids	2,451	5.43	Hired labor; steam-drill boat, dredge, dynamite.
1890	R. I. Rapids	1,398	7.20	"
1891	R. I. Rapids	2,704	5.76	"
1892	R. I. Rapids	1,990	4.73	"
1893	R. I. Rapids	2,919	4.71	"
1894	R. I. Rapids	3,852	4.70	"
1895	R. I. Rapids	6,158	3.75	"
1895	D. M. Rapids	....	3.05	"
1896	R. I. Rapids	5,271	4.42	"
1897	R. I. Rapids	3,105	4.31	"
1898	R. I. Harbor	....	4.94	"
1898	R. I. Rapids	6,320	3.37	"
1898	D. M. Rapids	5,449	2.36	"
1898	Henderson R.	693	4.14	"
1899	R. I. Rapids	5,406	3.50	"
1899	R. I. Harbor	1,441	2.47	"
1899	Rockingham	4,730	2.93	"
1900	R. I. Rapids	3,631	3.30	"
1901	R. I. Rapids	1,000	4.34	"
1902	R. I. Rapids	6,201	2.69	"
1903	R. I. Rapids	6,425	3.65	"
1904	R. I. Rapids	5,018	6.00	"
1905	R. I. Rapids	8,670	1.00	Dredging rock blasted preceding year.

LEVEES.

At a 6-ft. stage the river begins to overflow the bottom lands; above a 12-ft. stage the overflow of the alluvial valley is extensive, although there are certain sand ridges, that are above any recorded stage of the river. The floods are usually of short duration, and most frequently occur in June or July.

While there are many tracts of land that have been partially protected from overflow by their owners, there are but three levee districts along the Upper Mississippi river that have received appropriations from the General Government, i. e., the levee from Iowa river to Flint Creek, Warsaw to Quincy Levee, and Sny Levee.

Levee from Iowa River to Flint Creek.—The River and Harbor Act of August 17, 1894, provided for a survey on the west side of the Mississippi River:

> "* * * commencing at the mouth of Flint Creek, in Des Moines County, State of Iowa, and running along the west bank of the river to the mouth of the Iowa River. * * * with a view to improving the navigation by preventing the water from overflowing the natural and artificial banks along those parts of the river and deepening the channel."

This was interpreted to mean that Congress desired an estimate of the cost of a levee that would prevent overflow of the west bank of the river between the points mentioned. A survey was made in accordance therewith and an estimate of cost of $305,000 submitted. By the act of March 2, 1895, Congress appropriated $85,000 to begin the work, and to March 3, 1899, had allotted $300,000 for its construction.

The levee has a length of 35¼ miles and protects from overflow about 14,700 acres. The levee section originally adopted had a width of crown of 4 ft., land slope 1 on 2, and river slope of 1 on 3. The grade of crown is 3 ft. above the flood of 1888. When the writer was assigned to the charge of this district, in 1898, he increased the section by giving a width of 6 ft. to the crown and a land slope of I on 2½. The levee section adopted on the Lower Mississippi river, which has a crown from 8 to 10 ft. in width and a land slope of 1 on 3, it was believed, could be safely reduced, as the floods on the upper river are of shorter duration, and as great an increase in flood height from levee construction is not to be apprehended.

The method of levee construction was as follows: The ground occupied by the levee was first cleared of trees, stumps, and all other perishable matter, all trees and stumps being grubbed out by the roots to 3 ft. beyond the slope stakes. The surface of the ground was then thoroughly broken by spade or plow to form a bond with the earth deposited. The specifications required that such top soil as in the opinion of the engineer in charge was unfit for the foundation should be removed and deposited to form a banquette on the land side of the levee, together with such top soil from the borrow pits; but the ground along the levee was of such a character that little material was rejected. A muck ditch was then cut 3 ft. from the center line of the levee on the river side. Its dimensions usually were 4x4 ft. The object of the muck ditch is to explore the foundations and improve the bond between the foundation and the embankment. The muck ditch was then filled with approved material and thoroughly tamped, usually by teams passing over it. The embankment was then deposited in layers not exceeding 2 ft. in thickness when moved by scrapers (the usual method). If constructed by wheelbarrows, the specifications prescribed that the layers should not exceed 1 ft. in thickness and should be carefully tamped by employing one rammer to two wheelbarrows. The embankment was carried to one-tenth its height above the established grade to allow for shrinkage. The material was generally obtained from borrow pits on the river side, at a distance not less than 20 ft. from the base of the levee, but in a few cases it was necessary to obtain a small portion of the material on the land side, and in such cases the limit of the borrow pits was 60 ft. from the toe of the land slope.

As the levee line extends to the bluffs at the lower end of the district, to protect against back water, it has been necessary to make provision for the ordinary drainage of the land during rain storms. This has been accomplished by running pipes with outflow valves through the embankment at the various sloughs and streams it crosses, so that when the river is low, water can flow outward, but if high the closed valve would prevent an inflow. Ordinary 36-in. cast iron water mains were employed for the purpose, having a thickness of ⅞ in., the standard bell and spigot joint, and an average weight of 4,200 lbs., for lengths to lay 12 ft. The pipes were laid without calking the joints.

Three kinds of outflow valves have been tried. The first was an iron valve, about 5 ft. long, which cost $86.43. The second was also an iron valve, about one-half as long as the first, and with a flange on the lip, and planed faces, which made a tighter and better joint. This valve cost $70. But with both these valves it was found that a head of water of about 1 ft. was necessary to open the valve, unless a counter balance was provided. This counter balance consisted of an old rail attached to the valve by a wire rope and so pivoted as to take up the surplus weight. A wooden shutter, costing about $11 was, however, found to be much cheaper than either of the iron valves above mentioned. The objection to the wooden valves is their tendency to warp in such a manner as to allow considerable leakage. They are also more easily broken than the iron valves.

At the outlet of these drainage pipes were built rubble retaining walls to prevent earth from sliding in and filling the pipes; and an apron was also constructed to receive the outflow and prevent erosion. On the land side of the levee the entrances to the drainage pipes were protected by a rip rap of rock.

When the levee was exposed to wave wash, the slope was revetted with a layer of rip-rap about 9 ins. thick, extending from the toe of the slope to an elevation about 1 ft. below the high water of 1888. The length thus revetted was 14,770 ft. The rest of the levee slope was sown with grass seed, so as to form a sod to protect the embankment from rain wash.

It was occasionally necessary to construct the levee close to the bank of the river or a slough where it was liable to be injured by the caving of the banks. In such cases the bank was revetted. These shore protections were constructed in the manner customary on the Upper Mississippi river.

REMOVAL OF SNAGS AND OTHER OBSTRUCTIONS.

By the Act approved March 2, 1867, an appropriation of $96,000 was made for building and operating two dredge and snag boats. With this appropriation two steamboats were purchased and equipped with shears, for pulling snags, and with Long's Scraper, for lowering the crests of sand bars. Long's Scraper (Fig. 6), an invention of the late Colonel Stephen H. Long, Corps of Engineers, appears to have been the most successful of the various devices that have been suggested to temporarily improve navigation during low water. It consisted of a triangular frame of oak timber, with buckets or cutters of boiler iron bolted to the lower side. It was attached by bolts to the sides of the boat, and was raised or lowered by two ropes, one of which was fastened to the bow of the boat and passed under a pulley near the lower end of the frame, thence over a pulley on a bow sprit projecting from the boat, and thence to the forward steam capstan; the other rope was attached to the apex of the triangular frame passed over a pulley connected to the [illegible] boom, and thence to [illegible]. The method of operating the scraper was to moor the boat at the head of the shoal to be dredged, and to lower the scraper on the bar; the [illegible] of the dredge was then backed so as to drag the scraper over the bar, the boat drifting with the current down stream. After having been dragged across the bar the scraper was raised out of the water and the dredge returned to the initial point. The operation was then repeated until the desired depth was obtained. The buckets cut up and loosened the material on the bar and the current conveyed it down stream and deposited it in deep water, being assisted in the movement of the material by the river currents.

These scrapers were quite extensively employed until appropriations were made for the permanent improvement of the river, when dredges were substituted for them.

In the report of the Chief of Engineers for 1881, page 1185, it is stated:

> The results not being commensurate with the amount of time and labor required, comparatively little of this kind of work has been done of late years. So many bars scattered over the entire 700 miles of river becoming obstructions simultaneously at each recurring low water, it was found a hopeless task to keep them all open with one boat, and unless a channel is cut through and maintained the work cannot be considered successful. And again the results have no permanency, the work of the scraper being generally obliterated at each rise of the river, however slight, and in many cases a single night will destroy the work of the previous day. In increasing the depth on a bar for the time being the scraper is generally very effective and is now often used in special cases where it is thought that a channel once cut will maintain itself.

In such cases, however, it was found that the ordinary dipper dredge was more economical, and the work of the boat has been confined to snagging operations and the removal of wrecks and boulders.

Trees and stumps on caving banks fall or slide into the river and work out into the deepest channel water. These form what are called *snags*, and whether entirely under water or partly exposed are dangerous obstructions to passing boats and rafts. Many snags are brought into the main river from the tributaries in times of flood. Many lodge on bars or shoal places and lie there, perhaps for years, imbedded in sand, until changes in channel bring them in the way of boats. During the season of navigation the river is constantly patrolled. As the banks of the Upper Mississippi are comparatively low and generally sloping it is an easy matter to dispose of snags by hauling them out on the shore with the aid of tackle and levers, so that the expensive steam saws and other machinery used on snagboats on the Lower Mississippi, where the banks are high and steep, are not needed. A side wheel boat is preferable for ease of handling, and two hulls [illegible] to afford more space on the bow for the men and snagging apparatus. A strong pair of shears with large blocks extending over the bow for raising snags is mounted together with powerful steam engines.

One of the most important features of the snagboat work and one that has been much neglected is [illegible] the removal of snags in the [illegible] by the felling of large trees from the [illegible] bank.

According to figures of the U. S. Forest Service, more than 80,000,000 gallons of creosote and nearly [illegible] lbs. of zinc chloride were used in preserving timbers in the United States last year. Small quantities of crude oil, mercury bichloride and other chemicals were also used.

Roads and Streets Section

Note: This Section is devoted to methods and costs of road and street construction. It will cover road building in all its details, the construction of pavements, sidewalks and gutters, the testing and use of paving materials and the machinery and tools used in road building and paving.

The Theory of Economic Road and Street Design and Location.

V

In the preceding issues we have discussed pseudo-scientific methods of design, the fundamental law of economic design, estimating probable traffic (traffic survey), value of team time, cost of hauling per ton mile, and cost of macadam road maintenance per ton mile. We now come to the cost of interest per ton mile, deferring for the present the consideration of maintenance of other classes of pavement than macadam.

Cost of Interest per Ton-Mile.—This item depends obviously on three factors: (1) First cost per mile of road, (2) rate of interest, and (3) total tonnage carried per mile per annum.

The rate of interest at present ranges from 3 to 5 per cent on public loans, and may be taken at 4 per cent for illustration.

The first cost per mile depends very largely upon the *width* of the paved part of the highway. The engineer who is applying the rules of economics to highway design must cease using the square yard as his principal unit of cost. The mile—the unit of length—is the correct unit to use in solving transportation problems. When this unit is generally adopted, the practice of paving all roads and streets some "standard" width will cease. Then 18 to 24 ft paved streets for small towns, and 8 ft paved roads for light country traffic, will become much more common.

In estimating the item of interest per ton-mile, multiply the total average cost of a mile of highway by the annual rate of interest and divide by the total number of ton-miles to be hauled per annum.

The following tabulation will serve to show the importance of this item of interest per ton-mile, assuming the rate of interest to be 4 per cent:

Ton-Miles Per Annum	Interest Per Ton-Mile on Road Costing $1,000 per mile	$10,000 per mile
100	40.0 cts	400.0 cts
500	8.0 cts	80.0 cts
1,000	4.0 cts	40.0 cts
5,000	0.8 cts	8.0 cts
10,000	0.4 cts	4.0 cts
50,000	0.08 ct	0.8 cts
100,000	0.04 ct	0.4 ct

We now see how absurd are all general statements to the effect that paved roads can not be afforded in communities where the traffic is light. Certainly $10,000 a mile roads may not be warranted, but it does not follow that [illegible] roads that cost only $1,000 or $2,000 or $3,000 a mile.

Saving Per Ton-Mile Justifying Cost of Pavement.—We are now prepared to see [illegible] to give a [illegible] saving in the [illegible] of [illegible]. As we have seen [illegible] ton-miles that [illegible] will more than [illegible]. If on earth roads the cost of hauling is 20 cts per ton-mile, and on good macadam roads it is 10 cts, we see that [illegible] *the interest on the first cost of the road is much less than 10 cts per ton-mile.*

Referring to the table above again we see that if the traffic is only 100 ton-miles per annum (equivalent to 1 team hauling 10 ton-miles a day for 10 days in the year), the interest is 40 cts per ton-mile on a road costing $1,000 per mile. There are some localities, but not many, where a macadam pavement 8 ft wide and 4 ins. thick can be laid for $2 per cu. yd. of macadam, and it would have to cost even less than that to enable building such a macadam road, for it would require 450 cu. yds. of macadam per mile. However, there are innumerable localities where a first-class gravel road can be built for less than $1,000 a mile, even where the gravel is run through a crusher and a rotary screen to produce a graded product practically equal to crushed quarry-stone. Hence, even with so insignificant a traffic as 100 ton-miles per annum per mile of road, it must not be hastily assumed that no paving would be economic.

Let us assume that a series of parallel roads are to be built 2 miles apart, the length of each being 10 miles. Then each road will serve 20 sq. miles or 12,800 acres. If the crops are so meager that only ½ ton per acre is to be hauled over the road, we have 6,400 tons. Then dividing by 2 (according to the rule given in chapter II of this series), we have 3,200 ton-miles as the average annual traffic per mile of road. If 10 cts per ton-mile can be saved by a paved road, this would amount to 3,200 × 10 cts = $320 per mile per annum. Capitalizing this at 4 per cent we have $320 ÷ 4 per cent = $8,000 per mile as the justifiable expenditure for road paving.

To be strictly accurate we should deduct the 0.4 ct per ton-mile maintenance cost from the 10 cts saved by hauling over the paved road, and then multiply this 9.6 cts by the 3,200 ton-miles, and capitalize at 4 per cent, which is equivalent to multiplying the 3,200 ton-miles by 2.4 to arrive at the justifiable expenditure per mile, which is $7,680 in this case. From this we may formulate the following rule:

To determine the justifiable expenditure in dollars per mile for building a road (not including grading), [illegible] multiply the average annual number of ton-miles per mile of road by 2.4. This rule is based upon the data previously given, which indicates a cost of 20 cts per ton-mile on earth roads, 10 cts per ton-mile on paved roads, and 0.4 ct per ton-mile for the renewal of [illegible] pavement [illegible]. A similar rule can be readily deduced for any other conditions by deducting the cost per ton-mile of maintenance from the cost per ton-mile saved in hauling over a paved road, and then dividing by the rate of interest. The result is the factor used in the above rule, 2.4.

The foregoing calculations show [illegible] the building of [illegible] roads [illegible].

Thus far we have considered only the direct saving effected in team hauling on paved roads, but there are several other economic advantages secured by paved roads, which will now be considered briefly.

Other Economic Advantages of Paved Roads.—Beside the saving in the cost per ton-mile of heavy hauling, paved roads effect the following economies:

(1). Increase the number of days that a team can be worked annually.

(2). Crops yielding a greater tonnage per acre can be produced.

(3). Light loads (of butter, eggs, garden truck, etc.) can be hauled at greater speed.

(4). Market prices fluctuations can be taken advantage of.

(5). More markets are put within reach of the farmer.

(6). Car shortage in the fall can be greatly reduced.

(7). Likewise money shortage in the "crop moving season," by lengthening the crop moving season.

(9). Rural mail delivery and parcel delivery cheapened.

(10). Motor cars instituted, in part, for horse transportation, thus effecting still greater reduction in the cost of hauling.

This last consideration will soon become one of the most important elements to be considered in solving the problems of road economies, but as yet its effect need not be considered.

Economic Effect of Lengthening the Hauling Season.—This is a matter which may readily be made the subject of scientific investigation, although it never has been thus investigated. During the ordinary outdoor working season of 7½ or 8 months in the northern states, there are 26 days that might be worked if it were not for rainy weather, but in many states from 10 to 15 per cent of this time is lost on certain classes of outdoor work, due to rain and to the after-effects of rain upon the earth. These 2½ to 4 team days per month can be saved where there are paved roads and where there is produce to be hauled. In many localities fully 20 team days can be added to the working season in this manner.

Of the remaining 4 or 4½ months of the year, a very large percentage of time can be rescued from enforced idleness where paved roads are available for use. It is certainly conservative to say that 20 more team days can be added to the working season by building paved roads over which produce can be hauled in these winter and spring months.

If 40 hauling days are thus added, it may be that, in some cases, they can not be entirely used, due to lack of available produce to take to market. This is a subject for special investigation. But, if, for illustration, the investigation discloses that about half these days, or 20 days, can be utilized, and if team time is worth $3 a day, we have $60 saved per annum for every team that can be used in hauling over the road. Each hauling team to the mile of road would therefore justify an expenditure of $60 ÷ 4 per cent = $1,500 per mile of road to secure a paved highway. This $1,500 per hauling team must be added to the justifiable expenditure determined by the rule above given, for it represents an amount rescued from idleness. We therefore have the following rule:

To the expenditure per mile of paved road justified by the saving in the cost of transportation, add $75 per mile of road for every team-day that can be utilized by virtue of the lengthening of the working season effected by providing paved roads over which to haul.

A consideration of this rule and the one that precedes it enables us to understand why there is not a single unpaved road in England.

(To be continued)

An Analysis of Traffic on Seven Typical Highways in Rhode Island.*

BY A. H. BLANCHARD.†

The variability in the nature of the traffic to which suburban and country highways are subjected demands a careful analysis of economic and efficient construction and maintenance are to be characteristic of the work of highway engineers in the future.

Prior to the entrance of the motor car as an important integral element of highway traffic, the classification of highways and the consequent determination of the kind of surface adapted to that traffic and the efficient maintenance of the same were, to a certain extent, understood. Due to the fact that the only appreciable decrease in the amount of horse-drawn vehicle traffic has been caused by the partial substitution of the motor car for pleasure vehicles and cabs, the problem has not been changed materially in the case of city streets, excepting those built of macadam. On the other hand, the traffic to which many suburban and country highways are subjected has radically changed during the past five years.

TABLE I.—Traffic on Seven Typical Rhode Island Highways for Eight Consecutive Hours.

	East Providence 1906*	East Providence 1907*	Narragansett 1907†	South Kingstown 1905†	Warwick 1906*	Coventry 1905*†	Lincoln 1907*†
Motor car traffic:							
Runabouts	39	86	61	25	84	12	19
Touring cars—							
4 seats	155	157	162	101	159	9	18
7 seats, limousines, landaulets.	8	23	23	23	40	..	..
Motor cycles	10	21	20	..	6	1	..
Total motor car traffic	212	287	266	149	289	22	37
Horse-drawn vehicle traffic							
Commercial traffic—							
1-horse wagons, loaded, I. T.	4	16	1	2	11	27	49
1-horse wagons, loaded, R. T.	..	..	..	..	..	..	..
1-horse wagons, unloaded, I. T.	15	14	..	11	4	87	29
1-horse wagons, unloaded, R. T.	..	..	..	..	..	..	..
2-horse wagons, loaded, I. T.	..	..	..	4	..	25	6
2-horse wagons, loaded, R. T.	..	..	..	..	..	..	..
2-horse wagons, unloaded, I. T.	..	1	..	4	..	10	11
2-horse wagons, unloaded, R. T.	..	..	..	..	..	..	..
Other wagons, loaded, I. T.	..	..	..	..	..	1	..
Other wagons, loaded, R. T.	..	..	..	..	..	..	..
Other wagons, unloaded, I. T.	..	..	..	..	..	1	..
Other wagons, unloaded, R. T.	..	..	..	..	..	..	..
Pleasure vehicle traffic:							
1-horse vehicles, I. T.	13	38	10	8	21	67	5
1-horse vehicles, R. T.	21	98	6	4	42	7	..
2-horse vehicles, I. T.	..	1	..	1	1	..	..
2-horse vehicles, R. T.	2	13	..	..	4	..	..
Total horse-drawn vehicle traffic	55	181	17	34	83	225	100
Total traffic	267	468	283	183	372	247	137

* For period from 2 p. m. to 10 p. m.; † for period from 10 a. m. to 6 p. m.; *† for period from 8 a. m. to 4 p. m.

The primary factors in the analysis of traffic are the actual and relative amounts of horse-drawn vehicle traffic and motor car traffic and the speed at which the motor cars traverse the highways.

In an analysis of highway traffic it is obviously necessary to adopt a more or less detailed classification as a working basis. During 1908 the engineers of the State Board of Public Roads of Rhode Island used the following classification:

Motor car traffic:
  Runabouts.
  Touring cars, four or five seats.
  Touring cars, six or seven seats, including limousines and landaulets.
  Motor cycles.
Horse-drawn vehicle traffic:
  Commercial traffic—
    One-horse wagon, loaded, iron tires.
    One-horse wagon, loaded, rubber tires.
    One-horse wagon, unloaded, iron tires.
    One-horse wagon, unloaded, rubber tires.
    Two-horse wagon, loaded, iron tires.
    Two-horse wagon, loaded, rubber tires.
    Two-horse wagon, unloaded, iron tires.
    Two-horse wagon, unloaded, rubber tires.
    Other wagons, loaded.
    Other wagons, unloaded.
  Pleasure vehicle traffic—
    One-horse vehicle, iron tires.
    One-horse vehicle, rubber tires.
    Two-horse vehicle, iron tires.
    Two-horse vehicle, rubber tires.

The primary concepts governing the differentiation of highway traffic into the various classes upon which the following tables are based will be briefly explained.

The radical difference in the character of the wear of a macadam surface by horse-drawn vehicle traffic and motor car traffic does not require a detailed explanation. Nevertheless, it is advisable to emphasize the important difference, namely, that even high-speed motor car traffic does not cause abrasion, while heavy horse-drawn vehicle traffic does wear the macadam surface in appreciable amount. Again, granted aver-

TABLE II.—Traffic on the East Providence 1907 and Narragansett 1907 Roads from 10 a. m. to 10 p. m., July 19, 1908.

	E. Providence 1907 Road.	Narragansett 1907 Road.
Motor car traffic:		
Runabouts	109	63
Touring cars—		
4-5 seats	211	222
7 seats, limousines, landaulets	29	55
Motor cycles	31	2
Total motor car traffic	380	342
Horse-drawn vehicle traffic:		
Commercial traffic—		
One-horse wagons,		
Loaded, iron tires	24	1
Loaded, rubber tires	1	..
Unloaded, iron tires	36	..
Unloaded, rubber tires	1	..
Two-horse wagons,		
Loaded, iron tires	..	..
Loaded, rubber tires	..	..
Unloaded, iron tires	..	..
Unloaded, rubber tires.	1	..
Other wagons,		
Loaded, iron tires	..	..
Loaded, rubber tires	..	..
Unloaded, iron tires	..	..
Unloaded, rubber tires.	1	..
Pleasure vehicle traffic:		
One-horse vehicles, iron tires	51	15
One-horse vehicles, rubber tires	103	14
Two-horse vehicles, iron tires	1	..
Two-horse vehicles, rubber tires	19	..
Total horse-drawn vehicle traffic	238	30
Total traffic	618	372

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*Paper read before Section D of the American Association for the Advancement of Science, at the Baltimore meeting, December, 1908.

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age climatic conditions on a New England highway, for example, where macadam surface is well bonded together, a rapid disintegration will be caused by high-speed motor car traffic while horse-drawn vehicle traffic may more or less improve the same surface. The raison d'etre, therefore, for the initial division of traffic under the headings, motor car traffic and horse-drawn vehicle traffic is apparent.

The various divisions of motor car traffic are based upon a classification, depending upon the fact that the disintegration of a macadam surface caused by this class of traffic is a function of the two closely related variables, weight and speed.

TABLE III—TRAFFIC ON EAST PROVIDENCE 1907 ROAD, SUNDAY, AUG. 30, 1908, 8 A. M. TO 10 P. M.

	A. M.				P. M.										
	8-9	9-10	10-11	11-12	12-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	Total
Motor car traffic	3	4	5	2	6	8	5	13	7	13	15	18	6	7	112
Runabouts															
Touring cars	3	5	11	12	10	9	17	20	16	[illegible]	28	17	10	9	[illegible]
4-5 seats			2	2		2	2	1	2	1		1	2	1	16
7 seats, limousines, landaulets		2		1	7	6	2	6	8	3		1			26
Motor cycles															
Total motor car traffic	6	11	18	17	23	27	26	40	33	[illegible]	43	37	18	16	[illegible]
Horse-drawn vehicle traffic—															
Commercial traffic—															
One-horse wagons—Loaded I. T.	3		2	4	5	1	3	1	1	2	7	15	[illegible]	3	50
R. T.															
Unloaded I. T.	3	4	4	3	3	1		1		1					20
R. T.															
Two-horse wagons—Loaded I. T.	1										1				2
R. T.															
Unloaded I. T.															
R. T.															
Other wagons—Loaded I. T.															
R. T.															
Unloaded I. T.															
R. T.															
Pleasure vehicle traffic—															
One-horse vehicles—Iron tires	2	2	4	4	1	3	6	7	10	12	21	10	2	5	91
Rubber tires		1	6	4	4	11	15	21	27	28	27	18	7	3	172
Two-horse vehicles—Iron tires															
Rubber tires								1			5			1	7
Total horse-drawn vehicle traffic	9	7	16	15	16	16	24	31	38	43	61	43	12	12	343
Total traffic	15	18	34	32	39	41	50	71	71	93	103	80	30	28	[illegible]

The sub-division of horse-drawn vehicle traffic into commercial and pleasure traffic is advisable primarily on account of the difference in weight imposed on the surface of the road by the two classes of traffic. The further sub-division of each of the above classes depends mainly on two facts: (1) That wear caused by the impact of the hoofs of horses necessarily varies directly with the number of horses, and (2) that weight per square inch of the tire on the road surface likewise varies, although not directly, with the number of draft animals. The division of the various classes enumerated under commercial traffic into loaded and unloaded vehicles is dependent on the variation in weight. The final sub-division of all classes of horse-drawn vehicle traffic into vehicles with iron tires and those with rubber tires depends on the fact that the former causes infinitely more abrasion than the latter under similar conditions.

In this brief paper the traffic on seven typical highways in Rhode Island will be analyzed and discussed. The following descriptions of the various roads selected cover the essential characteristic features viewed from the standpoint of roadway traffic and the effect of the latter on the road surface.

TABLE IV—TRAFFIC ON EAST PROVIDENCE 1907 ROAD, FRIDAY, AUG. 28, 1908, 8 A. M. TO 6 P. M.

	A. M.				P. M.						
	8-9	9-10	10-11	11-12	12-1	1-2	2-3	3-4	4-5	5-6	Total
Motor car traffic:											
Runabouts	7	4	4	3	4	2	4	7	8	3	46
Touring cars—											
4-5 seats	15	9	8	4	8	11	21	13	25	13	127
7 seats, limousines, landaulets											
Motor cycles			1	2			2	1	1	1	8
Total motor car traffic	22	13	13	9	12	13	27	21	34	17	181
Horse-drawn vehicle traffic—											
Commercial traffic—											
One-horse wagons—Loaded I. T.	11	19	16	8	2	8	9	8	13	3	[illegible]
R. T.											
Unloaded I. T.	2	5	4	2	3	7	5	3	4	2	38
R. T.											
Two-horse wagons—Loaded I. T.	5	9	2	3	1	1			4	6	35
R. T.											
Unloaded I. T.		2			2	1		4		3	12
R. T.											
Other wagons—Loaded I. T.	1			1		1					3
R. T.											
Unloaded I. T.								1			1
R. T.											
Pleasure vehicle traffic—											
One-horse vehicles—Iron tires					3	1				1	21
Rubber tires	2	3	1								22
Two-horse vehicles—Iron tires											
Rubber tires											
Total horse-drawn vehicle traffic	26	18	23	14	11	19	21	29	33	21	235
Total traffic	48	31	36	23	23	32	48	50	67	38	416

The East Providence 1906 road is a part of the interstate trunk line connecting the cities of Providence and Fall River and an interstate trunk line passing through many towns and summer resorts. The surface was built of local stone, consisting of a mixture of chlorite gneiss and indurated sandstone. Continuous repairs have been necessary to prevent disintegration.

The East Providence 1907 road is a part of the same trunk line as the 1906 road. It is subjected to the traffic to three popular summer amusement resorts in addition to the traffic on the 1906 road. The surface was built of bituminous macadam with the surface of the No. 2 course bonded by grouting with coal tar or Texaco asphalt. The surface is in perfect condition at present.

The Narragansett 1907 road is a part of the interstate trunk line connecting Boston, Providence, Narragansett Pier, and New York. The surface was built of bituminous macadam without a sealed surface. The road is in perfect condition, while sections of ordinary macadam adjacent to this section have rapidly disintegrated.

The South Kingstown 1905 road is a part of the interstate trunk line connecting New York, Narragansett Pier, Newport, Providence and Boston. The surface was built of local granite. It has required continual repairs in order to prevent the rapid disintegration of the surface.

The Warwick 1906 road is a part of the same interstate trunk line as the Narragansett 1907 road. Due to its location near Providence it is a part of several intrastate trunk lines passing through thickly-settled districts. The surface was built of trap rock from Meriden, Conn. Continual ravelling and disintegration requires constant repairing.

The Coventry 1903 road is a part of an interstate trunk line passing through the central western part of Rhode Island and into Connecticut. At present about five miles remain uncompleted, hence the highway is practically a feeder to a typical country district of 70 sq. miles. The surface was built of trap rock from Meriden, Conn. Due primarily to ravelling, frequent repairs are necessary.

The Lincoln 1907 road is a part of an intrastate trunk line passing through a series of mill towns terminating in the city

TABLE V.—TRAFFIC ON NARRAGANSETT 1907 ROAD, SUNDAY, JULY 19, 1908, 10 A. M. TO 10 P. M.

	A. M.		P. M.										
	10-11	11-12	12-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	Total.
Motor car traffic:													
Runabouts	5	2	9	4	4	5	6	18	3	4	2	1	63
Touring cars—													
4-5 seats	2	19	20	19	26	26	30	28	31	13	6	2	222
7 seats, limousines, landaulets	..	4	3	1	1	3	11	10	13	7	1	1	55
Motor cycles	..	..	..	1	..	..	1	..	..	..	..	..	2
Total motor car traffic	7	25	32	25	31	34	48	56	47	24	9	4	342
Horse-drawn vehicle traffic:													
Commercial traffic—													
One-horse wagons—													
Loaded — I. T.	..	..	..	..	1	..	..	..	..	..	..	..	1
R. T.	..	..	..	..	..	..	..	..	..	..	..	..	...
Unloaded—I. T.	..	..	..	..	..	..	..	..	..	..	..	..	...
R. T.	..	..	..	..	..	..	..	..	..	..	..	..	...
Two-horse wagons—													
Loaded — I. T.	..	..	..	..	..	..	..	..	..	..	..	..	...
R. T.	..	..	..	..	..	..	..	..	..	..	..	..	...
Unloaded—I. T.	..	..	..	..	..	..	..	..	..	..	..	..	...
R. T.	..	..	..	..	..	..	..	..	..	..	..	..	...
Other wagons—													
Loaded — I. T.	..	..	..	..	..	..	..	..	..	..	..	..	...
R. T.	..	..	..	..	..	..	..	..	..	..	..	..	...
Unloaded—I. T.	..	..	..	..	..	..	..	..	..	..	..	..	...
R. T.	..	..	..	..	..	..	..	..	..	..	..	..	...
Pleasure vehicle traffic—													
One-horse vehicles—													
Iron tires	1	1	2	..	1	3	3	2	1	1	..	.	15
Rubber tires	..	1	2	..	2	2	1	3	1	1	1	..	14
Two-horse vehicles—													
Iron tires	..	..	..	..	..	..	..	..	..	..	..	..	...
Rubber tires	..	..	..	..	..	..	..	..	..	..	..	..	...
Total horse-drawn vehicle traffic	1	2	4	..	4	5	4	5	2	2	1	..	30
Total traffic	8	27	36	25	35	39	52	61	49	26	10	4	372

of Providence. The surface was built of local granite. The surface is in good condition, only ordinary repairs being necessary.

Table I contains a record of the traffic on the highways described above for a period of eight continuous hours. It was the intent to select normal periods for the various sections which would place them all on the same basis considering their location and the traffic to which they are subjected.

Tables II to V are described by their respective titles. In every case cited the traffic records are given for normal conditions.

The conclusions to be drawn from the records contained in Table I, taken in conjunction with the status of the macadam surfaces of the various sections referred to, are as follows:

(1) The amount of motor car traffic which will cause disintegration is much less than is generally supposed, as is shown by the amount and the effect of the traffic on the South Kingstown 1905 road.

(2) In the case of two roads subjected to practically the same amount of motor car traffic, the rate of disintegration will depend upon the location of the road, other conditions being equal. For instance, the rate of disintegration of the South Kingstown 1905 road is more rapid than in the case of the East Providence 1906 road, the former being located in an isolated district, the latter in the near vicinity of the city of Providence.

(3) The rate of disintegration of an ordinary macadam surface will vary almost directly as the percentage of motor car traffic. As examples of the above conditions the Coventry 1905 road and Warwick 1906 road, both built of trap rock, and the Lincoln 1907 and the South Kingstown 1905 roads both built of local granite are cited.

(4) The popular belief that trap rock is the ideal road material for the surface of all macadam roads independent of the nature of the traffic to which they are subjected is a fallacy. In the case of roads subjected to horse-drawn vehicle traffic consisting of pleasure and light commercial traffic, as for example, the Coventry 1905 road, or subjected to motor car traffic, either exclusively or in combination with light horse-drawn vehicle traffic, as for example, the Warwick 1906 road, and the trap rock surface is exceedingly expensive to maintain. This is due to the fact that very little dust is furnished by abrasion on account of the hardness of the broken stone, and hence, the binder being absent, the surface ravels under horse-drawn vehicle traffic or is disintegrated by motor car traffic.

(5) Bituminous macadam roads require a sealed surface when the highway traffic consists of a combination of heavy motor car traffic and heavy horse-drawn vehicle traffic, while the sealed surface is not a requisite when the road is subjected to only heavy motor car traffic. The East Providence 1907 road is an example of the first class of bituminous macadam roads, while the Narragansett 1907 road is characteristic of the second class. The sealed surface is considered necessary for the first class as insurance against the disintegration of the surface due to the liability of the loosening of the exposed No. 2 stone by blows from the hoofs of horses and the rapid enlargement of any break in the surface by motor car traffic.

Table II shows a more marked comparison between the two roads than Table I.

Tables III, IV and V have been included in this paper to show the actual distribution of traffic throughout the day and the improbability of being able to effectually control the speed of motor cars, especially in isolated districts, except by an extensive organization of state police.

Notes on Road Maintenance and Repairs.

In the spring of the year, on roads which have been drifted and on which the snow lies unevenly, the shallow places melt first, leaving the gravel or stone road exposed in spots, with mounds of snow on each side. Here the pounding action goes on. Wheels drop into depressions kept soft by the melting snow. Pitch holes commence, and a few days of traffic break up the road and do a great amount of injury.

Wheel tracks very soon form after a road is first metalled with gravel or broken stone, particularly if not thoroughly consolidated with a roller. In forming these tracks, a certain amount of the metal is forced downward by the wheels, but a greater portion is crowded outward. In this way, when wheel tracks are not filled, they become the weakest part of the road; whereas the portion of the road supporting the wheels should have the greatest strength. These tracks or ruts should not be allowed to remain in the road. But, when they have formed, they should be filled by drawing metal into them again with a grading machine or by the use of a rake. By giving constant attention to these tracks until the road is thoroughly consolidated, keeping the road in proper shape, and the road metal in place, the wheel tracks become what they should be, the strongest part of the road, almost as firm as two lines of solid stone. When once a well shaped road has been given a proper form and is thoroughly consolidated in this way, the subsequent cost of maintenance is greatly reduced.

Shoulders and edges of turf between the metal and the ditch should be cut off from time to time, taking care not to draw this sod and earth to the center of the metalled road, as some townships have done when using a grading machine. These shoulders are made up of dust washed from the center of the road, and they interfere with the ready flow of water from the wheel tracks to the side drains. This material, if returned to the top of a hard covering of gravel or stone, will destroy the road. It should be either thrown across the drains to the side of the road and leveled off, or gathered up in wagons and used to fill a low grade on an earth road, or wherever it can be used to advantage.

Whatever material is used in the construction of a road should be used in its repair. Holes and depressions on a clay road should be filled with clay; on a gravel road they should be filled with gravel, and on a stone road they should be filled with broken stone. If a soft material is used on a hard road, the hole will quickly reappear. If a harder material is used than the road is made of, two holes will be made instead of one.

If a pitch hole in a clay road is filled with stones or gravel, holes will be made by traffic on each side of the hard material. If broken stone is used to repair depressions and holes on a gravel road, a hole will be cut through on each side of the patch of broken stone, where wheels of wagons drop on the softer gravel.

Do not allow hollow, ruts or puddles to remain on the road, but fill them at once; if an earth road, use earth; if a gravel road, use gravel; if a stone road, use stone.

Deep holes in gravel and stone roads should have the earth and soft material cleaned out of them before putting in new metal.

Ruts and holes should be filled a little higher than the surface of the road so that there will not be a depression when the material is consolidated.

Keep weeds and sod cut away from the shoulders of gravel and stone roads by the occasional use of the grading machine.

Loose stones should be raked into piles to be taken up by a wagon and hauled away. The stone should be collected in a convenient place to be used afterward for crushing, putting into fills, or in such other manner as occasion may require.

All ditches and drains should flow freely in the early spring so that the cold water may be drawn away as quickly as possible, permitting the frost to come out of the ground.

If the ditches are not in condition to drain the macadam promptly, heavy loads will cut through the macadam into the wet and soft sub-soil, forming holes that are costly to repair.

The ends of culverts should be watched to see that they are not obstructed by leaves, grass and other material. Snow and ice should be removed from culverts whenever there is an accumulation likely to cause obstruction in case of a thaw. Special care should be taken in this respect prior to the time of spring freshets.

Water should never be allowed to stand or flow in the wheel tracks, especially on steep grades, care being taken to preserve the crown so that the water will flow to the side ditches.

Waste material from adjoining farms should not be allowed on the road. Any person using the roadside as a dumping ground for stone or other rubbish should be prosecuted. Noxious weeds and brush should be cut and removed.

For the surface of a stone road never use stones larger than will go through a 2-inch gage. Finer is preferable.

Use chips or screenings as a binding material on stone roads. Earth, sod, dust and similar soft material will ruin the best road ever built.

Do not allow dust and mud to lie on the surface of a gravel or stone road. Dust becomes mud in wet weather, and mud keeps a road in wet condition for weeks where it would dry in a few hours if the blanket of mud were removed.

The rake is a most useful tool for making repairs, and should be frequently used on gravel and stone roads to keep wheel tracks filled with the metal forced out of them. This is especially true during the first year after construction.

On earth roads establish a system of regular treatment with the "split log" drag.

Roads should receive constant attention. This is the most economical and satisfactory system of making repairs. Repairs should be made, not once a year nor twice, but as soon as signs of wear appear. Special attention is needed in early spring and early fall, as at these two periods much can be done to prepare the roads for the coming [illegible] conditions.

Bids are now being asked by the Porto Rico Irrigation Service for the construction of a portion of the irrigation system for Porto Rico. The work, bids for which are received June 11, includes the construction of about 21 miles of main canal with appurtenant structures, extending from the [illegible] and five reinforced concrete [illegible]. The estimated cost is $[illegible].

Unclassified and General Articles

Note: This section is devoted to methods and cost articles on construction work not properly coming under any of the preceding classifications.

General Specifications for the Design of Elevated Tanks and Stand Pipes.*

BY C. W. BIRCH-NORD, ASSOC. M. AM. SOC. C. E.

It is the writer's intention to submit herewith a general specification for the design of elevated tanks and stand pipes, which he wishes adopted by the engineering profession. As far as he knows this subject has never before been treated for this purpose, and it is therefore his most sincere wish that experienced engineers in this field will offer their most severe criticisms, in order to make the final revised specification a sound guide. Attention may be called to the fact that this specification has been used by the writer for some time, and has always been applied successfully.

The writer wishes to express his obligations to A. F. Reichmann, M. Am. Soc. C. E., and Mr. J. H. Hoff, for assistance in the preparation of this paper.

LOADS.

1.—The dead load shall consist of the weight of structural and ornamental steel work, platforms, roof construction, piping, etc.

2.—The live load considered shall be the contents of tanks, the movable load on platforms and roofs, and the wind pressure.

3.—The weight of water shall be assumed to be 62 lbs. per cu. ft., and that of crude oil 56 lbs. per cu. ft., 1 cu. ft. of fluid being equal to 7.48 gals.

4.—The live loads on platforms and roofs shall be taken at 30 lb. per sq. ft., or a 200 lbs. concentrated load applied at any point.

5.—The wind pressure shall be assumed at 30 lbs. per sq. ft., acting in any direction. The surfaces of cylindrical tanks exposed to the wind shall be calculated at two-thirds of the diameter multiplied by the height.

6.—The movable live load on platforms and roofs shall not be considered as acting together with the wind pressure.

UNIT STRAINS.

7.—All parts of the structure shall be proportioned so that the sum of the dead and live loads shall not cause the strains to exceed those given in Table I.

TABLE I.

	Pounds per sq. in.
Tension in tank plates (net section)	15,000
Tension in other parts of structure (net section)	[illegible]
Compression (reduced by formula)	[illegible]
Shear on rivets and pins	[illegible]
Shear on bolts and field rivets	[illegible]
Shear in plate girder webs	[illegible]
Bearing pressure on rivets and pins	[illegible]
Bearing pressure on field rivets	[illegible]
Fibre strain in pins	[illegible]

8.—For compression members the permissible unit strain of 16,000 lbs. shall be reduced by the formula:

$$p = 16{,}000 - 70\frac{l}{r}$$

where p = permissible unit strain in compression, in lbs. per square inch;

l = length of member, in inches, center to center of connections;

r = least radius of gyration of member, in inches;

the ratio $\frac{l}{r}$ shall never exceed 120 for main members and 150 for struts.

9.—Stresses due to wind may be neglected if they are less than 25 per cent of the combined dead and live loads.

10.—Unit strains in bracing and other members taking wind stresses may be increased to 20,000 lbs. per sq. in., except as shown in Section 9.

11.—The pressures given in Table II will be permissible on foundations and bearing plates.

TABLE II.

	Tons per sq. ft.
Soft clay	[illegible]
Ordinary clay	2
Dry sand and dry clay	[illegible]
Hard clay	[illegible]
Gravel and coarse sand	[illegible]
	Pounds per sq. in.
Brickwork with cement mortar	200
Portland cement concrete	[illegible]
First-class sandstone	[illegible]
First class limestone	[illegible]
First-class granite	[illegible]

DETAILS OF CONSTRUCTION.

12.—The plates forming the shells of cylindrical tanks shall be of different diameters, and shall be caulked from the inside. No foreign material shall be allowed when caulking.

In oil tank work, both the inside and the outside of the tank shall be beveled for caulking.

13.—Joints for horizontal seams and the radial seams in the spherical bottoms of tanks shall preferably be lap joints.

14.—For vertical seams lap joints shall be used for ¼, 5/16, and ⅜-in. plates; double butt joints for 7/16, ½, 9/16, ⅝ and 11/16-in. plates, and triple butt joints for ¾, 13/16, and 1-in. plates.

15.—Rivets, ⅝ in. in diameter, shall be used for ¼ and 5/16-in. plates; rivets ¾ in. in diameter for ⅜ to ⅝-in. plates inclusive, and rivets, ⅞ in. in diameter, for 11/16 to 1-in. plates, inclusive.

16.—Plates more than ⅝ in. thick shall be sub-punched and reamed.

17.—The minimum thickness of the plates for the cylindrical part shall be ¼ in. The thickness of the plates in spherical bottoms shall never be less than that of the lower ring in the cylindrical part of the tank.

18.—The [illegible] of the plates where the [illegible] tolerated will be [illegible] before the material is ordered.

19.—All plates shall be [illegible] planed for caulking.

20.—Radial courses of spherical bottoms shall [illegible] the columns supporting the tank shall be connected to the lower [illegible] when tanks are made [illegible].

21.—When the [illegible] of the cylindrical [illegible] is above the point of connection with the cylindrical part of the tank, there shall be [illegible] a girder or [illegible] to take the horizontal thrust. [illegible]

22.—The [illegible]

23.—The upper parts of columns [illegible] shall always be connected to the [illegible] of the cylindrical portion of the tank.

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*A paper read before the [illegible] Society of Civil Engineers, [illegible], and published in the Journal of the [illegible], Vol. XXXV, p. [illegible].

24.—In order to avoid eccentric loading on the tower columns, and local stresses in spherical bottoms, the connections between the columns and the sides of the tank shall be made in such a manner that the center of gravity of the column section intersects the center of connection between the spherical bottom and the sides of the tank. Enough rivets shall be provided above this intersection to transmit the total column load.

25.—If the tanks are supported on columns riveted directly to the sides, additional material must be provided in the tank plates riveted directly to the columns to take the shear. The shear may be taken by providing thicker tank plates or by reinforcement plates at the column connections, while bending moments shall be taken by upper and lower flange angles. Connections to columns shall be made in such a manner that the efficiency of the tank plates is not less than that of the vertical seams.

26.—For high towers, columns shall have a batter of 1 to 12. The height of the tower is understood to be the distance from the top of the masonry to the connection of the spherical bottom, or the flat bottom, with the cylindrical part of the tank.

27.—The bottom plates of stand-pipes shall be not less than 5-16 in. thick, and shall be provided with tapped holes, 1¼ in. in diameter, with screw-plugs spaced at 4-ft. centers to allow a filling of cement on top of the masonry, while the bottom part is being erected, in order to secure the proper bearing.

28.—Near the bottom of the stand-pipe there shall be provided one 12 by 18-in. manhole of elliptical shape.

29.—Near the top of each tank and stand-pipe there shall be provided one Z-bar acting as a support for the painters' trolley and for the stiffening of the tank. The section modulus of the same shall be not less than $\dfrac{D^2}{250}$, where D is equal to the diameter of the tank, in feet. If the upper part of the tank is held by the roof construction, this may be reduced.

30.—On large tanks, circular stiffening angles shall be provided in order to prevent the tank plates from buckling during windstorms. The distance between the angles shall be located by the following formula:

$$d=\sqrt{t}\,\frac{900}{D}$$

where, d = approximate distance between angles, in feet;
t = thickness of tank plates, in inches;
D = diameter of tank, in feet.

31.—The top of the tank will generally be covered with a conical roof of thin plates; and the pitch shall be 1 to 6. For tanks up to 22 ft. in diameter, the roof plates will be assumed to be self-supporting. If the diameter of the tank exceeds 22 ft., angle rafters shall be used to support the roof plates.

Plates of the following thicknesses will be assumed as self-supporting for various diameters:

3-32-in. plate, up to a diameter of 18 ft.
⅛-in. plate, up to a diameter of 20 ft.
3-16-in. plate, up to a diameter of 22 ft.

Rivets in the roof plates shall be from ¼ to 5-16 in. in diameter, and shall be driven cold. These rivets need not be headed with a button set.

32.—A trap-door, 2 ft. square, shall be provided in the roof plate. Near the top of the higher tanks a platform with a railing shall be provided, for the safety of the men operating the trap-door.

33.—An ornamental finial shall be provided at the top of the roof.

34.—A ladder, 1 ft. 3 in. wide, shall be provided from a point about 8 ft. above the foundation to the top of the tank, and also one on the inside of the tank. Each ladder shall be made of two 2½ by ⅜-in. bars with ¾-in. rungs. On large, high tanks, 30 ft. or more in diameter, a walk shall be provided from the column nearest the ladder to the expansion joint on the inlet pipe.

35.—In designing tanks, 6 in. additional height shall be allowed for over-run.

36.—The bracing in the towers shall be adjustable.

37.—The size of the anchor-bolts shall be determined by the uplift when the tank or stand-pipe is empty. The unit strains in the anchor-bolts shall not exceed 15,000 lbs. per sq. in., and the minimum section shall be limited to a diameter of 1¼ in.

38.—The concrete shall be assumed to have a weight of 140 lb. per cu. ft., and shall be sufficient in quantity to take the uplift.

39.—Any parts of the tank, stand-pipe, or tower, in which difficulties may arise in field riveting, shall be assembled in the shop, and marked properly before shipment.

40.—The structural material shall conform to the "General Specifications for Steel Railroad Bridges" by the American Railway Engineering and Maintenance of Way Association.

41.—The workmanship shall be in accordance with the Manufacturers' Standard Specifications of Feb. 6, 1903.

42.—Before leaving the shop all work shall be painted with one coat of approved paint, excepting the laps in contact on the tankwork. All parts which will be inaccessible after erection shall be well painted. After erection, the structure shall be covered with one coat of the same paint.

43.—Three-ply frost-proof casing shall be provided, if necessary, around the inlet pipe. This casing shall be composed of two layers of 1 by 2½-in. lumber, and each layer shall be covered with tar paper, and one outside layer of ⅞ by 2½-in. dressed and matched flooring. The lumber shall be in lengths of about 12 ft. A 1-in. air space shall be provided between the layers of lumber, and wooden rings or separators shall be nailed to them every 3 ft. The frost casing may be made square or cylindrical.

Results of Tests of Brick and of Terra Cotta Columns.

Thirty-two columns, 16 of brick and 16 of terra cotta blocks, have been tested at the University of Illinois Engineering Experiment Station and the results made public in a bulletin prepared by Profs. A. N. Talbott and D. A. Abrams. The length of the columns tested varied from 10 ft. to 12½ ft. The brick columns were 12½ ins. square and the terra cotta columns ranged from 8½ ins. to 17½ ins. square. The brick used in the construction of the columns were of two grades—an excellent class of building brick and a soft grade selected as representative of inferior brick. The terra cotta blocks were of good quality. Different qualities of mortar and different grades of workmanship were used. The loads were applied continuously to failure in most cases, but tests were also made with repeated applications of the same load. Central loading of the column was used in most cases, but in some tests the load was applied eccentrically.

Both brick columns and terra cotta block columns gave high strengths in all cases where strong mortar and care in building were used. For central loading the strength of the brick columns ranged from 3,220 to 4,110 lbs. per sq. in., and the strength of the terra cotta block columns from 2,700 to 3,790 lbs. per sq. in., the columns having the highest resistance not failing at the full capacity of the machine. The effect of the strength of the mortar is apparent in the carrying capacity developed in the columns. Lower loads were found in columns built with 1-5 Portland cement mortar than in those with 1-3 Portland cement mortar, still lower loads in those with 1-3 natural cement mortar, and still lower loads in those having 1-2 lime mortar. The effect of the quality of the brick is shown in the columns made with inferior brick, which carried only 31 per cent as much as columns built with the better grade of brick. In the case of the terra cotta columns, the blocks which were culled out as somewhat inferior gave a column strength perhaps 30 per cent less than the columns built with superior blocks. The effect of the attempt to represent hurried or careless workmanship in two brick columns and in three terra cotta block columns was a loss in strength of about 15 per cent and 25 per cent, respectively.

The ratio of the strength of the columns to the compressive strength of the individual brick and block is of interest. In the well-built brick columns loaded centrally, the ratio of strength of column to compressive strength of individual brick ranged from 0.31 to 0.37, and in the underburned clay brick column the ratio was 0.27. In the terra cotta block columns with central loading the ratio of strength of column to that of individual block was 0.74 for the incompleted test and 0.83, 0.85 and 0.89 for the others. If, as seems to be the case, the strength of the brick or block to resist crossbreaking is an element in determining the strength of the built-up column, a deeper or thicker brick would give higher column strength. It is possible that this partially accounts for the fact that the ratio is found to be higher for terra cotta block columns than for brick columns. The tests suggest that the ability of individual pieces to resist transverse strength is an important element in the strength of the completed column. This suggestion may have an important bearing on the advantageous size of the component blocks which may be used in a compression piece where high strength is desired.

The strength of the column is greater than the strength of the mortar cubes in both brick and terra cotta block columns, excepting only the soft brick columns which had brick of low compressive strength. It is evident that the strength of individual brick or blocks and the strength of the mortar both enter into the resistance of the column. The relative effect of the two depends upon the character of the material. It is evident, however, that the better the individual piece, the more important it is to have a mortar of high resisting strength.

The results obtained in applying the load eccentrically were found to agree very well with those obtained from ordinary analysis. When the amount of eccentricity in the application of the load is known or may be estimated closely, the ability of the column to resist this action may be calculated quite closely. It is apparent from the results that the calculated resisting stress in the column on the side of maximum compression is higher than that which causes failure in centrally loaded columns. The higher stress developed with eccentric loading is probably due to the influence of the restraint of the less stressed interior portion The tests made by applying and releasing a single load a number of times gave failures at loads below those which produced a failure in similar columns at a single application of the load The phenomenon is common in materials of the nature of brick and terra cotta

It is apparent that the quality of workmanship in laying up such columns has an important bearing upon the resisting strength. The work of building columns, however, is not difficult and requires only ordinary care Full joints and an even bearing are important, and the ordinary workman ought to be able to construct columns of high strength In the tests made on columns intended to represent poor or careless workmanship, the decrease in strength was not as much as anticipated However, it must be understood that careful and trustworthy work is essential and that a few poor joints will materially reduce the strength of the structure. Wherever good material and good workmanship are insured, the strength of masonry of this kind may be utilized with advantage

LETTERS TO THE EDITORS.

The Cost of Cellar Excavation with Revolving Steam Shovels.

Sirs Please advise me where I can get reliable information on costs of excavating basements for store buildings and the like with a small revolving steam shovel loading into wagons

The method and cost of excavating a cellar using a Thew revolving shovel were given in our issue of April, 1906, p. 107. A similar description also giving cost was published in our issue of April 15, 1905. In this second case the shovel used was a Browning.

Methods of Elevating Concrete Direct from Mixer and Chuting into Forms.

Sirs Is there any practical scheme for elevating concrete from the mixer and spouting it into forms for small jobs? Our particular problem is in country work—a silo 40 ft high this week next week a house 32x32 ft and 20 ft high, next month a store building 50x100 ft and 30 ft high or a stack 40 ft high mostly reinforced concrete The question is How can we get the concrete from the mixer to the forms? An outfit is wanted not too heavy to cart around the country and not too elaborate for small jobs

Practice affords a number of examples of plants for hoisting concrete direct from the mixer and dumping it automatically into elevated hoppers or bins from which it is spouted or chuted into the forms Such plants have been used mostly for large structures, but we see no reason why in modified form and smaller size they should not be adaptable to the class of work described by our correspondent The type of hoist is essentially a properly braced four column tower inside which the hoisting bucket travels up and down like an elevator When at the bottom of the tower the bucket stands under the discharge spout of the mixer By means of trips or other devices the bucket overturns partly at any desired point in the height of the tower and discharges its contents into a hopper supported on the tower or by independent staging It would appear to be a matter of no great difficulty so to construct such hoists that they could be taken down, loaded, transported by wagon and reerected The component steel or timber members of the tower could be arranged to bolt together, the bucket, cable, sheaves, etc, need not be large or heavy for small work, and chutes can be made of sections of galvanized steel pipes The hoist could be operated by the engine that operates the mixer Hoists of the type mentioned are made by the Ransome Concrete Machinery Co, Dunellen, N. J. the Wallace Hoist Sales Co, Ft. Wayne, Ind., the Municipal Engineering & Contracting Co., Chicago, Ill, the Chicago Concrete Machinery Co., Chicago, Ill. the T. L. Smith Co., Chicago, Ill A discussion of the possibilities of chuting concrete into forms will be found in ENGINEERING-CONTRACTING, April 7, 1907. "Concrete Construction—Methods and Cost," by Gillette and Hill also contains data on chuting and on concrete hoists. For not too great elevations, say under 30 ft., a plant resembling the familiar portable stone crushing plant so commonly employed in macadam roadwork would seem to be a possible solution of our correspondent's problem. The crusher would be replaced by a mixer, the screens eliminated and one bin or hopper used instead of two or more —Editors

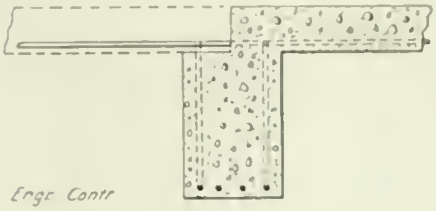

Fig. 1—Stopping Slab Over Girder.

The Proper Place for Stopping a Day's Run in Concreting Floor Slabs.

Sirs I am in a discussion with the architect's superintendent on some reinforced concrete work as to the proper or best place to stop a day's run, over a beam or between beams He contends that the joint should be made over a beam in the manner shown by Fig 1 My idea is that it should be broken between beams, as shown by Fig 2 I would appreciate it very much of you would cite me some authority on the subject or discuss it in Engineering-Contracting

Both of the methods of stopping off work which are described by our correspondent are sanctioned by practice, but the preference, perhaps, has been for the stop over the beam The necessity of selecting any particular point for stopping work rests, of course, on the assumption that perfect joints cannot be made between old and new concrete The idea is to make the joint—that is, to stop work—at the point where the resulting plane of weakness will least injure the strength of the slab Whether this point is directly over the beam or mid span of the slab, is a question of opinion If the stop is made over the beam it comes where there is neither shear nor bending moment, but where the reinforcement is most complex and, consequently, where a good joint is hard to secure It also makes uncertain any assumption of T beam action of the slab and beam If the stop is made at mid-span it comes where there is no shear and where the slab reinforcement is most simple, but where the bending moment is the greatest With the stop at mid-span the slab and beam can be molded together to give the T-beam section without joints. From these points it is easy to see how opinion may differ as it does as to choice of place for stopping off work in concreting slabs

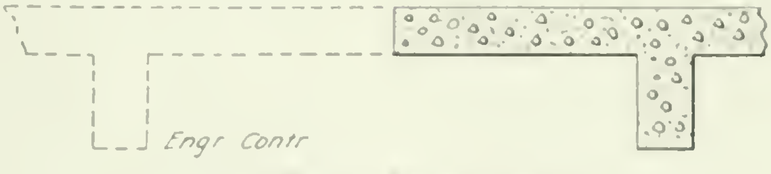

Fig. 2—Stopping Slab at Midspan.

Of late, practical constructors have shown a tendency to discount the importance of restricting stops or joints in slab work to certain predetermined places This has come about from the increasing evidence that, with reasonable care, practically perfect joints are practicable Assuming that perfect joints can be secured, it is clear that it is immaterial where work is stopped off In our issues of Feb. 24 and March 3, 1909, we presented a summary by Mr. E. P Goodrich, M Am Soc. C E., of tests made on concrete joints. As a result of this summary and of a series of tests made by himself, Mr Goodrich concludes that, if proper bonding methods are adopted, with acid and grout, work may be stopped along 45-degree planes at any point in a beam, at pleasure, between the ends and the third points

Practically the same position is taken by Mr Ernest McCullough in his paper printed in our issue of April 14, 1909 Mr Goodrich's discussion referred to above is particularly complete and should be read by our correspondent and all other concrete workers interested in the question of joining new concrete to old —Editors

Amounts of Water Required for Different Mortor and Concrete Mixtures.

Sirs In a recent contract consisting of 3,000 ft of curbing, and 36,000 sq ft of sidewalks a dispute has arisen over the amount of water used The water company at this point has no meters depending altogether on guess work for the amount of water furnished contractors and their guesses are always high enough The curbing is 18 ins in height and 6 ins broad, 8 ins exposed above the ground The back side of the curbing is not faced the sidewalk is composed of 3 ins of concrete base, and 1 in top dressing The concrete in both the sidewalk and curb is composed of 1 part cement 2½ parts sand and 5 parts gravel the top dressing in both the curb and the sidewalk composed of 1 part cement to 2 parts sand

This work was laid late in the fall and the concrete was mixed very stiff I estimated the amount of water used by the method shown in Gillette's "Hand Book of Cost Data," page 266, and made the amount of water used between 16,000 and 17,000 gallons. I would like this amount checked and confirmed if it is correct by the Engineering-Contracting. I do not wish to take up the time of your men for nothing, but as I intend to do a good deal of work at this point, it is a matter of considerable importance for me to get some understanding about the amount of water charged for by the water company.

The amount of water required for any specified mortar mixture depends first, of course, upon the consistency or degree of wetness of the mixture. Our correspondent describes the mixture employed by him as being "very stiff." Consistency or degree of wetness being fixed, the amount of water required to produce that consistency will depend upon the age, fineness and character of the cement, upon the amount of voids in and the nature of the sand and upon other conditions. None of these influencing data appear in our correspondent's inquiry. The answer requested, therefore, must be based on an assumption of average conditions. It is also assumed that the stone with which the mortar is mixed to make concrete does not take up any material amount of the mixing water; otherwise another variable is introduced and one to which it is hard to give a value.

The rule mentioned by our correspondent as it is given in "Concrete Construction Methods and Cost," by Gillette and Hill, is as follows:

Multiply the parts of sand by 8, add 24 to the product and divide the total by the sum of the parts of sand and cement.

This rule is true only for wet mixtures such as are most commonly employed at present; it gives more water than is required for a very stiff mixture so that its use in the case mentioned by our correspondent is liberal to the water company. It gives the percentage by weight of water required. These percentages for various mortar mixtures commonly employed are:

Mortar	1-1	1-1½	1-2	1-2½	1-3	1-4
Per cent water	16	14.4	13⅓	12.6	12	12.2

To obtain the quantity of water required in gallons solve the following equation:

$$\frac{(C w+S w^1)\ P}{8.355}=x \text{ in which}$$

C = volume of cement in barrels.

S = volume of sand in cubic yards.

w = weight of cement pounds per barrel.

w^1 = weight of sand in pounds per cubic yard.

P = per cent of water determined by rule.

8.355 = weight in pounds per gallon of water.

x = gallons of water per cubic yard.

To illustrate by an example we will take a 1-2½ mortar, assuming the sand to have 35 per cent voids, a barrel of cement to yield 3.65 cu. ft. of paste and to contain 3.8 cu. ft. of cement. From Table X in "Concrete Construction—Methods and Cost" we find that 1 cu. yd. of 1-2½ mortar under the conditions assumed requires 2.45 barrels of cement and 0.9 cu. yd. of sand. From the rule given above we find that a 1-2½ mortar requires 12.6 per cent by weight of water. Substituting these values in the equation given we have:

$$\frac{[(2.45\times380)+(0.9\times2900)]\ 12.6}{8.355}=x=53 \text{ gal.}$$

The quantities of water given in Tables I, II and III have been calculated in this manner. For cement the standard weight of 380 lbs. per barrel is assumed. For sand a weight of 2,900 lbs. per cu. yd. has been assumed for Table I, and of 2,500 lbs. per cu. yd. for Table II; these are about what silicious sand containing 35 per cent and 45 per cent voids, respectively, will weigh. For average sand we may assume a weight of 100 lbs. per cu. ft., or 2,700 lbs. per cu. yd., which is the weight assumed in computing Table III.

Turning now to the specific example given by our correspondent we have in 36,000 sq. ft. of 3-in. base slab 36,000 × ¼ = 9,000 cu. ft.; 9,000 ÷ 27 = 334 cu. yds., and we have in 36,000 sq. ft. of 1-in. finish 36,000 × $\frac{1}{12}$ = 3,000 cu. ft.; 3,000 ÷ 27 = 112 cu. yds. From Table I we find that 1 cu. yd. of 1-2 mortar requires 54 gals. of water; then 112 × 54 = 6,048 gallons of water required for top finish. From Table III we find that 1 cu. yd. of 1-2½-5 concrete requires 23 gallons of water; then 334 × 23 = 7,682 gallons of water required for base slab. A curb 18 in. × 6 ins. has a cross section of 0.75 sq. ft.; then 3,000 × 0.75 = 2,250 cu. ft. = 16.3 cu. yds. Then 16.3 × 23 = 1,065 gallons is the amount of water required for the curb. Adding, we have 6,048 + 7,682 + 1,065 = 14,795 gallons of water required for the concrete. The estimate of our correspondent would, therefore, seem to be very liberal, assuming no greater waste and amount of use for miscellaneous purposes than is reasonable.—Editors.

Table I.—Ingredients in 1 Cubic Yard of Mortar.

(Voids in sand 35%; 1 barrel of cement yielding 3.65 cu. ft. paste; barrel specified 3.8 cu. ft.)

Proportions	1-1	1-1½	1-2	1-2½	1-3	1-4
Barrels cement	4.09	3.33	2.81	2.45	2.16	1.62
Cu. yds. sand	0.6	0.7	0.8	0.9	1.0	1.0
Gals. water	63	57	54	53	53	47

Table II.—Ingredients in 1 Cubic Yard of Mortar.

(Voids in sand 45%; 1 barrel cement yielding 3.4 cu. ft. of paste; barrel specified 3.8 cu. ft.)

Proportions	1-1	1-1½	1-2	1-2½	1-3	1-4
Barrels cement	4.32	3.61	3.10	2.72	2.16	1.62
Cu. yds. sand	0.6	0.8	0.9	1.0	1.0	1.0
Gals. water	60	58	54	53	48	41

Table III.—Ingredients in 1 Cubic Yard of Concrete.

(Sand voids 40%; stone voids 45%; 1 barrel cement yielding 3.65 cu. ft. paste; barrel specified 3.8 cu. ft.)

Proportion	1-2-4	1-2-5	1-2-6	1-2½-5	1-2½-6	1-3-4
Barrels cement	1.46	1.30	1.18	1.13	1.00	1.25
Cu. yds. sand	0.41	0.36	0.33	0.40	0.35	0.53
Cu. yds. stone	0.82	0.90	1.00	0.80	0.84	0.71
Gals. water	26	23	21	23	20	27
Proportion	1-3-5	1-3-6	1-3-7	1-4-7	1-4-8	1-4-9
Barrels cement	1.13	1.05	0.96	0.82	0.77	0.73
Cu. yds. sand	0.48	0.44	0.40	0.46	0.43	0.41
Cu. yds. stone	0.80	0.88	0.93	0.80	0.86	0.92
Gals. water	25	23	21	21	19	18

A Question of the Sufficiency of ΣM, ΣMx and ΣMy in Arch Design.

Sirs:—Having been engaged lately on the design of arches, I have renewed the acquaintance with ΣM, ΣMx and ΣMy, and the three equations, in which they occur, namely,

$\Sigma M=O$ $\Sigma Mx=O$ and $\Sigma My=O$. After this more intimate acquaintance with them I have ceased to look upon them with the same favor as formerly and would like to raise the question of their innate virtues and the justification of their claims as the equations "par excellence" for the calculation of an arch.

I recognize that their simplicity of form and the apparent facility of their application are attractive, and I believe that therein are found the reasons why they so strongly appeal to us. However, great objections may be made against their continued use, and I will endeavor to state them and partly show them in the following, and I think that my views in this matter will be accepted by many who have had occasion to deal with one or more of the problems that are connected with the design of a roof arch.

In the first place, the equations are in themselves meaningless from the point of view of the intelligence, and lead to a methodical way of calculation which would not be so objectionable if the mind could clearly follow the proceeding throughout. In their application, besides, a very strange method of consideration is followed—a method that never should have been tolerated—much less developed. This odd conception of conditions, or cause and effect, as it may more properly be termed, is in regard to the deformation of the arch. The arch is assumed free to move out at one end—the tangent there remaining in a parallel position, under influence of the stresses, caused by the loads and the vertical components of the reactions. A similar virtual displacement is then assumed to be caused in the opposite direction under influence of a force applied at that end and directed toward the other end, where it finds its reaction. This conception is understood by the method of reasoning in graphical work and has found its expression in "*the closing line of the neutral axis as a polygon* for some kind of loading not mentioned" (being unmentionable).

Now we may, in dealing with the hinged arch, assume one end free to move—in or out—as the loads may direct, and also a horizontal force to bring it back. This conception is rational enough, in fact, imposed by the theory of elasticity, but in the case of a rigid arch such a conception is not very lucid, to say the least, and, therefore, not to be encouraged. Together with ΣMx it leads to a confusion of ideas, from which rise mental obstructions, interfering with a good view of the arch problem in the light, in which we wish to look at it. As they stand, the equations are only applicable to the very limited number of cases of symmetrical loading. With unsymmetrical loading, as wind-loads, which occur in almost every case of a roof arch, the equations do not furnish the assistance the designer expects. Although true, they are not exactly what is required, for they impose the obligation to return to their original form for the determination of the anchoring moments. This many do unconsciously.

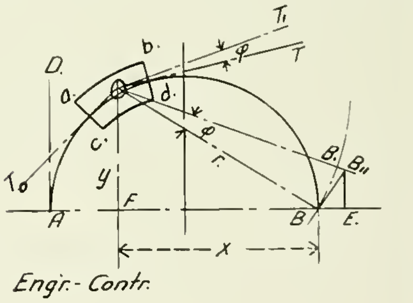

Fig. 1.

The application of the principle of least work to the calculation of arches suggests efforts to introduce more rational ideas than those illustrated by the aforesaid equations, but there are probably greater difficulties to the majority of designers to be met with in the use of this way of calculation.

In spite of the confusion which they often cause—either in one form or in another—ΣM, ΣMx and ΣMy are very popular with the greater number of writers of text books on arches, and how far they enjoy the popularity among the designers I cannot say, but I am inclined to think that they are in great favor, judging only from the great ease with which they allow them to pass over rather great difficulties often unknowingly.

Whether ΣMy first saw the light in the pages of the Encyclopedia Brittanica (Chapter on Bridges) or not, I do not know, but it is to be found there anyway as one of the coordinates or components of the assumed or virtual displacement of one end of the arch relative to the other under influence of the stresses, caused by the bending moments, which are due to the loads and the vertical components of the reactions. ΣMx is not referred to in the Encyclopedia, but it follows as a natural consequence from the reasoning, that evolves $\Sigma My=O$, that $\Sigma Mx=O$. It is not literally expressed in the article, that the tangent at the other end is considered fixed, but such [illegible] and it is not to be regretted that this way is not [illegible] by the author. It might [illegible] an [illegible] of [illegible] the other [illegible] ΣM_x [illegible] in a way that would [illegible] it [illegible] for all [illegible] the [illegible]. The [illegible] of ΣM [illegible] are [illegible] wrong because the equations [illegible] right.

An arch [illegible]

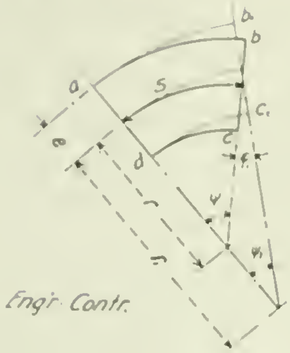

Fig. 2.

[illegible] for ΣM, ΣM_x and ΣM_y respectively to the deformation caused by the bending moments which is easily understood from the equations.

Fig. 1 represents the center line of an arch held in its geometrical position at A. The end B is supposed to be entirely free and the reaction there represented by a vertical force. An element $abcd$ of the arch, when subjected to stresses from bending moments, would change to ab_1c_1d (Fig. 2), if the conditions to the left of ad were the actual ones. This expresses the condition of fixity of the tangent at A, OT_0, the tangent to the neutral axis at ad remaining in its position. At the other end of the element the tangent OT changes its position to OT_1, making an angle "ϕ" with its former position, the tangential deviation of the element, which angle thus in its way represents the deformation of the element under influence of the average bending moment "M" within it. This is generally found about its center O, the coordinates of which are x and y. These coordinates may be assumed to be also the coordinates of the points of intersection of the tangents before and after the deformation. If TOB be considered a rigid system of lines, its position will shift to T_1OB_1 with the deformation, BB_1 being the displacement at B corresponding to the tangential deviation ϕ of the element. A line BB_{11} is now drawn at right angle to OB and its intersection with OB_1 *produced* is then the accepted position of B after the deformation of the element. This is an approximation effected on the strength of the smallness of the angle involved, which entitles us to consider *the arc* BB_1 equal to *the tangent* BB_{11}. But the real approximation consists therein that the horizontal and vertical projections on AB and AD of BB_1 and BB_{11} respectively are assumed to be alike.

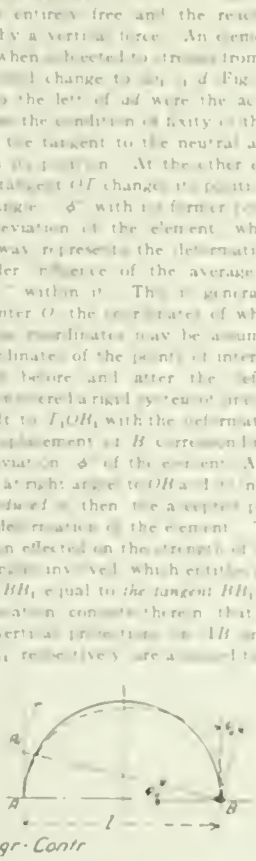

Fig. 3.

This approximation is the more remarkable, as a correct expression for the virtual displacement is found in ϕr when $r = OB$. Through this approximation are the expressions ΣM_x and ΣM_y however evolved. Drawing $B_{11}E$ at right angle to AB we have $\angle BB_{11}E = \angle OBF$. Then follows from the similarity of the triangles $BB_{11}E$ and OBF, that

$$\frac{BB_{11}}{BE} = \frac{r}{y} \text{ and } \frac{BB_{11}}{B_{11}E} = \frac{r}{x}, \text{ but } BB_{11} = \phi r$$

$$BE = \frac{\phi r}{r}\, y = \phi y \text{ and } B_{11}E = \frac{\phi r}{r}\, x = \phi x.$$

If now the arch be [illegible] divided into a number of similar small elements and the [illegible] displacements at B due to the [illegible] of each element for the [illegible] which are assumed will be added together we have $\Sigma BE = \Sigma \phi y$ and $\Sigma B_{11}E = \Sigma \phi x$. Now [illegible]. A reaction force [illegible] at B, directed toward A, which causes bending moments of opposite sign within the elements, the effects of which naturally are to cancel the [illegible] in the [illegible].

Thus $\Sigma \phi y = 0$ and $\Sigma \phi x = 0$.

Seeking now another expression for the angle ϕ which is the result of the difference in stresses in the outer and inner chords due to the bending moments, we find the following relations between the various factors of the deformation. The radii of the center line before and after the deformation are r and r_1 (Fig. 2), corresponding to the center angles ψ and ψ_1. The change in lengths of the extreme fibers of the cross section at a distance "e" from the center line is $ab - ab_1$. As $ab = \psi (r + e)$ and $ab_1 = \psi_1 (r_1 + e)$, we get $ab - ab_1 = \psi (r + e) - \psi_1 (r_1 + e) = \psi r - \psi_1 r_1 + (\psi - \psi_1) e$ and $ab - ab_1 = \phi_1 e$, when $\phi_1 = \psi - \psi_1$ and $\psi r = \psi_1 r_1$.

(The latter is an approximation, for the neutral axis of a curved element does not coincide with the center line but falls slightly inside the same.) $ab - ab_1$ may also be expressed in the length "s" of the element on the center line:

$\frac{ab}{s} = \frac{r+e}{r} = 1 + \frac{e}{r}$, $ab = \left(1 + \frac{e}{r}\right) s$ and if $\frac{1}{E}$ be the coefficient of elasticity, the change in length of ab for a unit stress G is $\left(1 + \frac{e}{r}\right) s \frac{1}{E} G$. $G = \frac{M}{I/e}$ (the ordinary moment eqn. of the theory of elasticity), in which I is the moment of inertia and I/e the

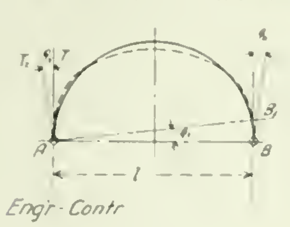

Fig. 4.

moment of resistance of the cross section, M the bending moment there and "e" as before.

Thus $\phi_1 e = s\left(1 + \frac{e}{r}\right)\frac{1}{E}\,\frac{M}{I/e}$ and $\phi_1 = s\left(1 + \frac{e}{r}\right)\frac{M}{EI}$.

For the inner chord an angle $\phi_{11} = s\left(1 - \frac{e}{r}\right)\frac{M}{EI}$ is obtained. The uniformity of the coefficient of elasticity permits us, however, to consider the plane [illegible] a plane after the deformation, that is $\phi_1 = \phi_{11}$ or $\phi = \frac{\phi_1 + \phi_{11}}{2} = \frac{M}{EI} s$, when it becomes plain that the neutral axis passes inside the center line of the arch because $\phi_1 > \phi_{11}$. This expression for ϕ or the tangential deviation of the element is inserted in the equation $\Sigma \phi y = 0$ and $\Sigma \phi x = 0$, when we obtain $\Sigma \frac{M s y}{EI} = 0$ and $\Sigma \frac{M s x}{EI} = 0$.

From these equations may such factors be eliminated which are common for all the terms of the summation, as E and the ratio $\frac{s}{I}$. If I be uniform throughout the arch, the arch should be divided into elements of the same length on the center line. If I be variable, it is always possible to divide the arch so that the lengths of the elements are in proportion to the moments of inertia of their cross sections. Thus the equations will become

$$\Sigma M y = 0 \text{ and } \Sigma M x = 0.$$

These equations are true for an arch rigidly [illegible] at one support A and free at B, [illegible] bending moments [illegible] B [illegible] looking at the arch [illegible] they represent a [illegible] which may easily be [illegible] arithmetically or graphically, but without the [illegible] equations $\Sigma M y = 0$ and $\Sigma M x = 0$ with $\frac{M}{EI}$ it is not easy to understand the meaning of [illegible]. The equations are [illegible] [illegible] $\Sigma \phi y = 0$ and $\Sigma \phi x = 0$ [illegible] a meaning [illegible] that [illegible] as the parameters of the virtual displacement at B. The [illegible] altering the arch [illegible] at A [illegible] by Fig. 3. The arc AB represents [illegible] the [illegible] of the tangent there is [illegible] to form a rigid system of lines with the arch. Should the [illegible] at A now be removed we would [illegible] the [illegible] arch, and the tangent at A would deviate an angle ϕ_1 (Fig. 4). AB will take the position AB_1, deviating an angle ϕ_1 as well, and the distance BB_1 on the vertical through B [illegible] to this angle will be $\phi_1 l$. This is still better seen by drawing the elastic line of a straight girder (Fig. 5). The ordinates between the curve and

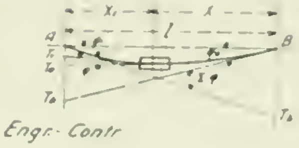

Fig. 5.

the straight line AB represent the deflection at any point, and the tangents to the curve are the tangents to the neutral axis. For a small element the end tangents T_1 and T_{11} form an angle ϕ which is the tangential deviations of this element for the average bending moment within it. On account of the smallness of the deflection compared to the length of the span, ϕx_1 may be considered to be represented by T_1T_{11}. As the tangent to the neutral axis changes its position gradually from AT_0 to BT_0, AT_0 will represent $\Sigma \phi x_{11}$ or $\phi_{11} l$ when l is the length of the span, and BT_0, $\Sigma \phi x$ or $\phi_1 l$. ϕx and ϕy for an arch may be understood in a similar way by drawing a line OB_0 parallel to AB through the center of the element (Fig. 6), which line with the ordinates may be considered as a rigid system of lines with the tangent T. When T deviates an angle ϕ, the tangent T_0 remaining in position, it represents the tangential deviation of the element, and OB_0 and y will also deviate an angle ϕ. The lengths subtended by these angles on BB_0 and AB will then represent ϕx and ϕy, respectively. That $\Sigma \phi x = 0$ and $\Sigma \phi y = 0$ for a rigid arch is then plainly seen. The tangential deviation ϕ_1 at A represents a sum of tangential deviations of all the elements of the arch, which sum together with the tangential deviation ϕ_{11} at B, which also represents a similar sum, form the total tangential deviation of the arch $\Sigma \phi = \phi_1 + \phi_{11}$ (Figs. 4 and 5).

Either ϕ_1 or ϕ_{11} may be $= 0$, according to which end is rigidly held, when $\Sigma \phi x = 0$ and $\Sigma \phi x_1 = 0$ respectively, the x's being measured from the free

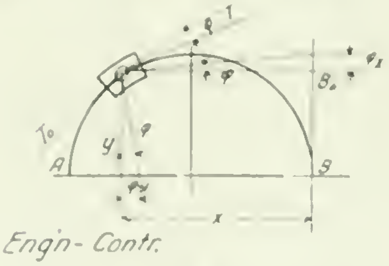

Fig. 6.

end. That the eqs. $\Sigma \phi x = 0$ or $\Sigma M x = 0$ do not hold when the anchoring moment at A is removed, that is for the hinged arch, should thus be fairly comprehensible.

For a rigid arch both ϕ_1 and $\phi_{11} = 0$ and $\Sigma \phi = \phi_1 + \phi_{11} = 0$ or $\Sigma M = 0$ as $\phi = \frac{Ms}{EI}$.

The eq. $\Sigma M = 0$ is not, however, sufficient, although true enough for a rigid arch, for with equal tangential deviations ϕ_1 and ϕ_{11} at the ends—one positive and the other negative—$\Sigma\phi=\phi_1+\phi_{11}=O$.

It is evident that the eqv. $\Sigma M=O$ is not essential to the solution of the rigid arch, for if an arch with one end anchored may have the conditions at this end laid down by the eqv. $\Sigma Mx=O$, the same equation will express the conditions of the other end as well, if anchored, provided the x s be measured from the other end. However, the equations $\Sigma M=O$ and $\Sigma Mx=O$ are generally used to determine the anchoring moments, with the help of a proceeding, described as "*taking the resultants of the moments and making them balance.*" This may be accepted as theoretically true, but the proceeding is not one which a designer should follow.

It may be said that it would be far better, in the true interests of the student, if the text-books on arches would use more generally the equations

$$\Sigma\phi=O,\ \Sigma\phi x=O \text{ and } \Sigma\phi y=O, \text{ with } \phi=\frac{Ms}{EI}.$$

instead of the less easily understood equations $\Sigma M=O$, $\Sigma Mx=O$ and $\Sigma My=O$, how true the latter ever may be. The frequency of their occurrence and use leave, indeed, all recollection of their relationship to ϕ soon far behind in the obscurity of an uninteresting past. A fact, which is the more regrettable, as $\Sigma\phi$, $\Sigma\phi x$ and $\Sigma\phi y$ really are very essential for the work.

A direct method of calculating an arch is, of course, very desirable, but it must be, above all, a clear proceeding that may be easily followed by anyone familiar with ordinary work.

Reference has already been had to the principle of least work and its application to the calculation of an arch. This is but another way of utilizing the theory of elasticity, of which the virtual displacement is an expression. However, as it seems to be necessary to deal with the tangential deviations in order to determine the anchoring moments in unsymmetrically loaded rigid arches in an intelligent manner, it would seem well still to observe the tangential deviations in the calculation of an arch, but in a somewhat clearer form than presented by the equations $\Sigma M=O$, $\Sigma Mx=O$ and $\Sigma My=O$.

As stated, they are only of direct aid in the case of a symmetrically loaded arch. Their application is then a matter of great simplicity, because it may be *guessed* that the anchoring moments are alike, without the use of the equation $\Sigma Mx=O$.

$\Sigma M=O$ alone determines the moments and $\Sigma My=O$ the horizontal thrust. Thus the moments due to the dead load are easily obtained, but for an unsymmetrical load the equations leave the determination of the anchoring moments, which *must* be estimated before the horizontal thrust can be computed, almost as much of a problem as it were before. The equations are, as far as I can see, of a fundamental character only and do not serve the purpose of calculating an arch in a satisfactory manner. The wind loads and the anchoring moments are, in fact, problems in connection with the design of roof arches, of which I have failed to find among printed matters on the subject any practical solutions directly applied to the arch.

Yours truly,
E. R. T. Berggren, M. E.

New York, March 22, 1909.
520 W. 162 St.

In the Empire Construction District of the Central Division of the Isthmian Canal, 14 shovels on April 13, 1909, excavated 22,693 cu. yds. of rock and earth in eight hours, an average of 1,621 cu. yds. per shovel for the day. On the same date, 15 shovels working in the Culebra Construction District, Central Division, excavated 25,165 cu. yds., an average of 1,678 cu. yds. per shovel for the day.

A new feature of the coming session of the Summer School of the University of Wisconsin, which begins June 28, will be courses in Public Utilities testing and accounting, for those desiring to become familiar with the requirements of the Railroad Commission of Wisconsin, which has the administration of the Wisconsin Public Utilities Law.

Personals.

Mr. H. A. Rowland has resigned as City Engineer of Wellington, Kan.

Mr. Bert C. Wells has been reappointed City Engineer of Wichita, Kan.

Mr. Edward Wilhelm has been appointed City Engineer of Bay City, Mich.

Mr. E. A. Kingsley has been re-elected Superintendent of Public Works of Little Rock, Ark.

Mr. William A. Aycrigg has been appointed City Engineer of Omaha, Neb., to fill the vacancy caused by the death of Andrew Rosewater.

Mr. Adna Dobson has assumed his duties as City Engineer of Lincoln, Neb., succeeding Mr. Wm. Grant, who was not a candidate for re-election.

Chambers & Hone, Consulting Engineers, of New York City, have removed their offices to the 18th floor of the German American Insurance Bldg., 1 Liberty St., New York.

Mr. Alexander Potter, Consulting Engineer, of New York City, has been elected an honorary member of the Association of Managers of Sewage Disposal Works of Great Britain.

Mr. R. A. McClanathan, formerly Assistant City Engineer of Niagara Falls, N. Y., has been appointed City Engineer, succeeding Mr. W. D. Robbins, who has become engineer for the Board of Water Commissioners of the city.

Mr. George H. Burgess, heretofore Principal Assistant Engineer of the Erie R. R., has been appointed Chief Engineer of the Delaware & Hudson R. R., with headquarters at Albany, N. Y., succeeding Mr. James McMartin, resigned.

Mr. Carl S. Dow, late Publicity Manager of the B. F. Sturtevant Co., and formerly in charge of Instruction and Text Book Departments of the American School of Correspondence, has become associated with the staff of Walter B. Snow, Publicity Engineer, of Boston, Mass.

Jean Bart Balcombe, formerly Chief Engineer of the Pittsburg Filter Mfg. Co., and General Manager of the Hudson River Concrete Co., has opened offices at 184 La Salle St., Chicago, Ill., where he will engage in a consulting practice making a specialty of hydraulic and hydro-electric enterprises.

Mr. George W. Cravens has opened an office in the Fort Dearborn Bldg., Chicago, Ill., where he will engage in consulting practice, making a specialty of the mechanical, electrical and structural designs of power plants. Mr. Cravens was formerly with the General Electric Co., at the Lynn and Schenectady Works, and later was with the Goodman Mfg. Co., of Chicago.

Mr. Parker U. Cole, formerly eastern advertising representative of Engineering-Contracting, has, with Mr. James S Barron, of New York City, formed the company styled James S. Barron, Inc., and will continue the general sales business heretofore carried on by Mr. Barron. Among the equipment they will handle are the Nims concrete mixer, the 20th Century grader, and the Peerless hand sweeper. Mr. Cole's former associates on Engineering-Contracting wish him every success in his new undertaking.

Mr. John J. Harmon, M. E., has become a member of the Harmon Engineering Co., of Peoria, Ill., and the firm, in addition to surveys and civil, municipal and drainage engineering, will give particular attention to mechanical engineering problems. Mr. John J. Harman has been connected with the Link Belt Co.; the Acme Harvester Co., as Chief Draftsman; University of Illinois, teaching machine design and steam laboratory work; U. S. Geological Survey, fuel tests; National Tube Co., Kewanee Works, as Mechanical Engineer.

Mr. Dwight T. Randall, late engineer in charge of fuel tests, Technological Branch, United States Geological Survey, has associated himself with the Arthur D. Little Laboratory of Engineering Chemistry of Boston, in charge of the Department of Fuel Engineering. Mr. Randall, who is a graduate of the University of Illinois, was formerly connected with R. W. Hunt & Co., and Westinghouse Church Kerr & Co., and later was in charge of the Steam Engineering Laboratory of the University of Illinois, and of steam and boiler tests at the St. Louis Exposition.

The average daily number of laborers employed on actual construction work on the Isthmian Canal during March was 14,319.

Catalogs Worth Having.

Engineers and contractors should have on file the latest catalogs of machines, tools and supplies that they use. In sending for catalogs reviewed or advertised in this paper, you will confer a favor on us if you will write direct to the advertisers and state that you saw the catalog mentioned in Engineering-Contracting. If you are in the market for tools, machinery or supplies, tell us and we will notify promptly the leading manufacturers.

No. 1218. **Testing Machines.**—Riehle Bros. Testing Machine Co., Philadelphia, Pa.

An elaborate catalog of 108 pages, illustrating and describing testing machinery of all kinds, and appliances to be used with the machines.

No. 1219. **Rock Drills.**—Harold L. Bond Co., 42 Broadway, New York.

A circular telling of the merits of the Wood rock drills sold by this company.

No. 1220. **Wagons.**—Acme Wagon Co., Emigville, Pa.

A 56-page catalog telling of the wagons manufactured by this company. Besides the wagons meant for ordinary use, this company makes a stone spreading wagon and a drop bottom dump wagon.

No. 1221. **Dump Wagon and Excavating Machinery.**—Indiana Road Machine Co., Fort Wayne, Ind.

A well-illustrated catalog describing the National elevating graders, the National dump wagons, road machines, scrapers and the Fort Wayne stone crusher.

No. 1222. **Wagons.**—The Studebaker Bros. Mfg. Co., South Bend, Ind.

In this catalog are described the various style of dump wagon, bottom and end dumps, and dump carts, manufactured for contractors' use and for collecting ashes and garbage in cities.

No. 1223. **Specifications for Using White Portland Cement Mortar.**—By Albert Moyer, Berkshire White Portland Cement Co., New York, N. Y.

Describes the manufacture and characteristics of the white Portland cement made by the above named company and gives specifications for its use in both exterior and interior work. A valuable pamphlet for the architect and builder.

No. 1224. **Grading Machines.** — Smith & Sons Mfg. Co., Kansas City, Mo.

Describes, illustrates and gives directions for operating the wheel, buck and drag scrapers, railroad and township plows, dump wagons, road machines, stone crushing outfits, revolving screens and road rollers made by the above named company. The pamphlet has 72 pages and the descriptive matter is good.

No. 1225. **Reinforced Concrete.** — The International Fence & Fireproofing Co., Columbus, O.

A 16-page pamphlet describing the main structural features of the system of reinforced concrete construction controlled by the above named firm. Beam and slab tables are given.

No. 1226. **Beam and Column Data.**—Northwestern Expanded Metal Co., Chicago, Ill.

This is No. 5 of the valuable series of little pamphlets containing data for reinforced concrete design which is being published by the above named company. This particular pamphlet gives data for calculating beams and columns; it is a veritable manual on the subject.

CONTRACT NEWS

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We shall welcome any news notes that our readers may send in. Notes of contracts awarded, bidding prices, etc., will be especially acceptable.

BIDS ASKED

Bridges.

Bids Open.		See Issue
May 12	Chicago, Ill	May 12
May 13	Dayton, O	Apr. 21
May 13	Laconia, N. H	May 5
May 14	Cincinnati, O.	Apr. 21
May 17	Mansfield, O	Apr. 28
May 17	Morristown, N. J.	May 12
May 18	Cedartown, Ga	May 5
May 18	McNab, Que.	May 5
May 18	Batavia, Ill.	May 12
May 20	Canton, O	May 5
May 20	Mitchell, S. Dak	May 5
May 20.	Savanna, Ill	May 12
May 21	Cleveland, O	Apr. 21
May 21	Gaspe, Que	Apr. 28
May 24.	Salem, Mass	May 12
May 24.	Malvern, Ark	May 12
May 24	Cleveland, O	May 5
May 24	Franklin, Pa	May 12
May 24	Findlay, O	May 12
May [illegible]	[illegible] Ont	May 5
May 31	Fremont, O.	May 12
June 1	Toronto, Ont	May 12
June 4	Toledo, O	May 12
July 1	[illegible], O	Apr. 21
Aug 24	Cedar Rapids, Ia	Apr. 14

Buildings.

———	Carroll, Ia	May 12
May 12	Belvidere, Ill	Apr 7
May 12	Danville, Ill.	Apr. 14
May 12.	Utica, N. Y.	Apr 28
May 12.	Danville, Ill	Apr 14
May 12	Middletown, N. Y	May 5
May 12	Rochester, N. Y.	May 5
May 13	Elmwood Place, O	May 5
May 14.	Washington, D. C.	Apr. 28
May 14	St Paul, Minn	May 5
May 14	Harrisburg, Pa	May 12
May 15	Fort Reno Remount Depot, Okla	Apr 21
May 17	Northfield, Vt	Apr 28
May 17	Fort Pierce, Fla	Apr. 21
May 17	Harrison, Ark	May 5
May 17	Portland, Ore	May 5
May 17	National Soldiers' Home, Va	May 12
May 18	Delaware, O	Apr 28
May 18	Orange, Va	May 12
May 19	Washington, D. C.	May 5
May 20	Fort Leavenworth, Kan	Apr 28
May 20	[illegible], Ia	Apr 28
May 20	Chicago, Ill	May 12
May 20	Chicago, Ill	May 12
May 21	Columbus, O	May 12
May 22	East Lansing, Mich	Apr 28
May 24	Eureka, Cal	Apr 21
May 24	Fort Ward, Wash	Apr 28
May 24	Boston, Mass	May 12
May 24	Fort Wm. H. Harrison, Mont	May 12
May 25.	White Earth, Minn	May 12
May [illegible]	Madison Barracks, N. Y	May [illegible]
May 26	Columbus Barracks, O	May [illegible]
May 27	Klamath Agency, Ore	Apr 28
May 27	Fort Totten, N. Y	May [illegible]
May 27	New York, N. Y	May 12
May 29	San Angelo, Tex	Apr 28
May 31	Texarkana, Tex	Apr 28
May 31	Fort Screven, Ga	May [illegible]
May 31	Victoria, B. C.	May 12
May 31	Fort Crockett, Galveston, Tex	May 12
June 1	Tacoma, Wash	May [illegible]
June 1	Canton, N. Y	May 12
June 1	Wilmington, Del	May [illegible]
June 2	Danville, Ky	May [illegible]
June 3	Fort Andrews, Mass	May 12
June 7	Fernandina, Fla	May 12
June 9	Clifton Forge, Va	May 12
June 1[illegible]	Fort Sill, Okla	May 12
June 1[illegible]	Alexandria, La	May 12
June 15	Mayfield, Ky	May 12

Roads and Streets.

May 12	Columbus, O	Apr 21
May 12	Cleveland, O	Apr 21
May 12	Mobile, Ala	Apr 21
May 12	Tipton, Ind	Apr 28
May 12	Roslyn, Va	May 5
May 13	Chicago, Ill	May 5
May 13	Milwaukee, Wis	May 12
May 13.	Milwaukee, Wis	May 12
May 14	Paulding, O.	Apr 21
May 15	Ashton, S. C.	Apr 21
May 15	Cleveland, O	Apr. 21
May 15	Marion, Ind	Apr 28
May 17	St Charles, Mo	May 5
May 15	Coraopolis, Pa	May 12
May 15.	Georgetown, Ky	May 12
May 15.	Washington, D. C.	May 12
May 15.	Washington, D. C.	May 12
May 17	Bowling Green, O	Apr 21
May 17.	Fort Monroe, Va	Apr 28
May 17.	Rockville, Ind	Apr 28
May 17.	Roanoke, Va	May 12
May 17	New York, N. Y.	May 12
May 17	Albany, N. Y.	May 12
May 17.	Wellington, Kan.	May 12
May 17.	Owosso, Mich.	May 12
May 18	Menasha, Wis	Apr 28
May 18.	Circleville, O	May 5
May 18	Norwalk, O	May 12
May 18	Troy, N. Y.	May 12
May 19	Ridgefield Park, N. J.	May 5
May 19.	Chicago, Ill.	May 12
May 20.	Rainier, Ore	May 5
May 20	Lake Mills, Wis	May 5
May 20.	Winnipeg, Man	May 5
May 21.	Paulding, O.	Apr. 28
May 21.	Mt. Gilead, O.	Apr 28
May 21.	Cleveland, Ohio	May 5
May 22.	Chicago, Ill	May 5
May 22.	Westerville, O.	May 5
May 24.	Ashland, O.	May 5
May 25	McAlester, Okla.	May 12
May 25.	Steubenville, O.	May 12
May 25.	St. Clairsville, O	May 12
May 25.	Rushville, Ind	May 12
May 26.	New Brunswick, N. J.	May 5
May 26.	New Brunswick, N. J.	May 5
May 27.	Scottdale, Pa.	May 12
May 27.	Fort Snelling, Minn	May 12
May 28.	Cincinnati, O.	May 5
May 28	Fort Monroe, Va	May 12
May 29.	Cleveland, O.	May 12
June 1.	Jackson, Tenn.	May 12
June 1	Pensacola, Fla.	May 12
June 3.	Fulton, Mo.	May 12
June 7.	Liberty, Ind.	May 12
June 8.	Vincennes, Ind.	May 12

Sewers.

May 12.	Mobile, Ala.	Apr 21
May 12.	Baltimore, Md	Apr 28
May 12	Rye, N. Y.	May 5
May 13.	Danville, Ia.	May 5
May 14	Huron, S. Dak.	Apr 14
May 14	Louisville, Ky.	May 12
May 17.	Oshkosh, Wis	May 5
May 17.	Evansville, Ind.	May 12
May 17	Albany, N. Y	May 12
May 17.	Clear Lake, Ia	May 12
May 18	Syracuse, N. Y	Apr. 21
May 18	Provo, Utah	May 5
May 18	St Thomas, Ont	May 12
May 19	Brooklyn, N. Y	May 12
May 19	Chicago, Ill	May 12
May 21	Louisville, Ky	May 5
May 21	Louisville, Ky	May 5
May 21	Angola, Ind	May 12
May 21.	Youngstown, O	May 12
May 22	Oberlin, O	May 5
May 24	Las Animas, Colo	May 5
May 24	Carlsbad, N. Mex	May 5
May 26	Albert Lea, Minn	Apr 28
May 28	Seattle, Wash	May 12
May 28	Wadsworth, O	May 12
May 31	Frackville, Pa	Apr 28
June 8	Toronto, Ont	May 12
June 10.	Albert Lea, Minn	May 12

Water Supply.

May 12	Galveston, Tex	Apr 21
May [illegible]	Fort Sam Houston, Tex	May [illegible]
May 12	Ridgeway, Pa	May [illegible]
May 1[illegible]	Albert Lea, Minn	May 1[illegible]
May 1[illegible]	[illegible], O	May [illegible]
May 1[illegible]	Kingston, Ont	May 12
May 1[illegible]	Marion, Ind	May 12
May 17	[illegible], Cal	Apr 28
May 18	Toronto, Ont	Apr 28
May 19	Estevan, Sask	Apr 21
May 19	Chicago, Ill	May [illegible]
May 20	Glens Falls, N. Y	May [illegible]
May 20	Concord, Mass	May 12
May 20	Bowling Green, Ky	May 12
May 22	East Cleveland, O	May 12
May 24	McAlester, Okla	May 12
May 26	[illegible], Sask	May 12
May 27	[illegible], Ill	May 12
May [illegible]	Chester, Pa	May 5
June 1	Lawrenceville, Pa	Apr 28
June 2	Springfield, Mass	May 12

Miscellaneous.

———	Toronto, Ont.	Underground Conduit,	May 12
May 12	Augusta, Ga.	Flood Protection,	Apr 28
May 12	Columbus, O.	[illegible] Culverts, Etc.,	May 5
May 1[illegible]	Fort Bliss, Tex.,	Bowling Alley,	May 12
May 17	Jacksonville, Fla.	Building Jetties,	Apr. 28
May 17	Washington, D. C.,	Riprap Jetties,	Apr 28
May 20.	Missoula, Mont	Wire Fencing,	Apr. 28
May 20	Clifton, Ariz.,	Railroad Work,	Apr 28
May 20	Wilkesbarre, Pa.,	Street Lighting,	May 12
May 20.	Cleveland, O.,	Timber Trestle,	May 12
May 22.	Hawaii,	Dry Docks,	Mar. 31
May 24	Louisville, Ky.,	Underpass,	May 5
May 26.	Roland, Ark.,	Lock,	Mar. 31
May 26.	Philadelphia, Pa.,	Signals, Etc.,	Apr 28
May 27.	Rock Island, Ill	Dam Construction,	May 5
May 27.	New York, N. Y.,	Stone,	May 5
May 28.	Cleveland, O.	Light House and Beacon,	Apr. 21
May 29	Washington, D. C.,	Torpedo Boats,	Mar. 31
May 31.	Moose Jaw, Sask.,	Sinking Test Well,	May 12
June 1.	Bridgeport, O.,	Street Lighting,	Apr 28
June 1	New Orleans, La	Tow Boat,	May 12
June 7.	Superior, Wis.,	Stone and Pebbles,	May 12
June 8	Ashland, Wis.,	Riprap,	May 12
June 8	Wheeling, W. Va	Dam Work,	May 12
June 28	Galveston, Tex.,	Causeway,	May 5
July 1	Boston, Mass.,	Street Lighting,	May 12

Excavation, Earth and Rock.

May 12.	Northwood, Ia.	Drainage Ditch,	Apr. 21
May 12	Fort Dodge, Ia.,	Ditch,	Apr. 28
May 12.	Dakotah, Ia.	Ditch Work,	May 5
May 15.	Orland, Ill.,	Deepening Channel,	Apr 21
May 15.	Mare Island, Cal.,	Dredging,	Apr. 21
May 17.	Greenville, Miss	Levee Work,	May 5
May 18	Barstow, Tex	Drainage System,	Apr. 28
May 18	Manitowoc, Wis.,	Dredging,	May 5
May 18	Milwaukee, Wis	Dredging,	May 5
May 22	Valparaiso, Ind	Ditch,	May 12
May 22	Washington Barracks	Filling,	May 12
May 24	Baltimore, Md	Dredging,	Apr 28
May 24	Des Moines, Ia	Tile Drain,	Apr 28
May 24	Baltimore, Md	Dredging,	May 5
May 24	Kenton, O	Dredging,	May 12
May 2[illegible]	Redwood Falls, Minn	Ditch Work,	May 12
May 2[illegible]	Fort Moultrie, S. C.	Dredging,	May 12
June 1	Baltimore, Md	Dredging,	May 5
June 1	Baltimore, Md	Dredging,	May 5
June 2	Jefferson, Ia.,	Ditch Work,	Apr 28
June 4	San Diego, Cal	Dredging,	May 12
June 7	Baltimore, Md	Dredging,	May 12
June 14	Guayama, P. R.	Irrigation Work,	May 12

Materials, Machines, Supplies, Etc.

———	Mobile, Ala	Asphalt Repair Plant,	May 12
May 12	Washington, D. C.	Movable Towers,	Apr 21
May 12	Governors Island, N. Y. H.	Hardware, Etc.,	Apr 28
May 12	Baltimore, Md	Fence,	May 5
May 12	Baltimore, Md		

Gymnastic Apparatus, May 5
May 12. Columbus, O., Portland Cement, May 5
May 13. New York, N. Y., Crushed Rock, May 5
May 13. Knoxville, Tenn., Metal Vault, May 5
May 14. Wheeling, W. Va., Cement, Apr. 21
May 14. Watertown, Mass., Ordnance Supplies, Apr. 21
May 14. Honolulu, H. I., Cement, Apr. 7
May 15. West Point, N. Y., Building Materials, Apr. 21
May 17. Watervliet, N. Y., Iron, Steel, Etc., Apr. 28
May 17. Augusta, Ga., Steel, Nails, Etc., Apr. 28
May 17. Washington, D. C., Cars, Barrows, Jacks, Etc., Apr. 28
May 17. Jeffersonville, Ind., Boilers, Canvas, Etc., May 5
May 17. New York, N. Y., Pumps, Boilers, May 5
May 17. Lethridge, Alberta., Pump, May 5
May 17. Pittsburg, Pa., Motor Cycle, May 12
May 17. Philadelphia, Pa., Freight Elevator, May 12
May 17. Yonkers, N. Y., Engine, Dynamo, Etc., May 12
May 19. Rushville, Ind., Engine, Generator, Etc., Apr. 21
May 19. Washington, D. C., Hardware, Rules, Etc., Apr. 28
May 19. Seattle, Wash., Metal Shelving, May 12
May 19. Baltimore, Md., Grass Destroyer, May 12
May 21. Madison, S. Dak., Gas and Electrical Equipment, May 12
May 21. Washington, D. C., Lathes, Tools, May 12
May 22. Toledo, O., Generators, Gas Engines, Etc., May 5
May 24. Washington, D. C., Cranes, Buckets, Etc., May 5
May 24. Rock Island, Ill., Ordinance Supplies, May 5
May 24. Leavenworth, Kan., Refrigerating Plant, May 5
May 24. Bemidji, Minn., Fire Hose, May 12
May 24. Washington, D. C., Cranes, Buckets, Etc., May 12
May 26. Dover, N. J., Rope, Iron, Etc., Apr. 28
May 26. Philadelphia, Pa., Ordinance Supplies, May 5
May 27. Chicago, Ill., Pumping Engines, May 5
May 27. Fort Monroe, Va., Screens, May 12
May 31. Leavenworth, Kan., Derick Materials, May 5
May 31. Atlanta, Ga., Cement Testing Apparatus, May 12
June 1. Manila, P. I., Pipe, Etc., Mar. 31
June 1. Fort Totten, N. Y., Automatic Anchors, May 12
June 2. Vancouver, B. C., Water Pipe, May 5
June 5. Key West, Fla., Conveyor System, May 12
June 9. Brownsville, Pa., Air Compressor Plant, May 12
July 1. Manila, P. I., Gate Valves, Hydrants, May 12
July 9. Pretona, Transvaal, Drills, May 12

BIDS ASKED

Bridges.

Bids are asked on following work, the notes being arranged alphabetically by states:

Malvern, Ark.—Until May 27, by Andrew T. Roland, County Judge, for construction of two steel bridges over Ouachita River at Green's Ferry and Grigsby's Ford. The Green's Ferry bridge is to consist of one main span, 160 ft. long, substructure tubular piers 60 ins. in diameter, 38 ft. long, with two end spans of 100 ft. each, to be supported by concrete abutments; one roadway 16 ft. wide. The bridge at Grigsby's Ford is to be according to same plan and specifications, except end spans are to be 110 ft. long each.

Batavia, Ill.—Batavia Township is reported to be calling for bids until May 18 for constructing two bridges, one a concrete bridge 25-ft. span, 16 ft. wide; the other of steel 42-ft. span, 8 ft. wide.

Chicago, Ill.—Until 11 a. m., May 12, by Department Public Works, for erection of a concrete arch bridge over the Illinois and Michigan Canal at South Kedzie Ave.

Salem, Mass.—Until 10 a. m., May 24 (readvertisement), by James P. Hale, County Clerk, for sealed bids for rebuilding the old Chain bridge over the southerly arm of the Merrimac River, between Newburyport and Amesbury. The work will consist of removing all necessary portions of the old structure and building complete new anchorages, cables, steel stiffening trusses, towers, steel floor beams, and wooden floor, with a short solid fill approach between reinforced concrete walls. The length of floor of suspended span is about 226 ft.

Savanna, Ill.—Until 2 p. m., May 20, by Highway Commissioners, Geo. W. Bristol, Chairman, at office Town Clerk, for constructing two steel and concrete bridges, one steel culvert and three stone arch culverts. Plans, etc., with Town Clerk.

Morristown, N. J.—Until May 17, by Sewer Commissioners, for constructing concrete bridge over Whippany River to carry main sewer pipe.

Findlay, O.—Until noon, May 29, by John A. Sutton, County Auditor, for material and labor for constructing reinforced concrete bridge over Hagerman Run in Marion Township. Certified check for $100 required with bid.

Fremont, O.—Until May 31, by County Commissioners, for constructing steel bridge with creodone floor over Muscalonge Creek in Jackson Township.

Toledo, O.—Until 10 a. m., June 4, by D. T. Davies, Jr., County Auditor, for constructing superstructure of a bridge over Swan Creek on County Road No. 125 in Waterville Township; also for the construction of two concrete abutments and for the repair of bridge across County Road No. 289 at the intersection of Road No. 464.

Franklin, Pa.—Until May 29, by County Commissioners, for constructing bridge over mouth of French Creek. Bids are asked on concrete arches or steel structure 987 ft. long. Certified check for $5,000 required with bid.

Toronto, Ont.—Until noon, June 1, by the Chairman of the Board of Control, City Hall, Toronto, for the reconstruction of the bridges on Dundas St. over the tracks of the Grand Trunk and Canadian Pacific Rys., consisting of the following work: Supply of five new trusses of the following spans: 105 ft. 4 ins., 93 ft., 86 ft. 8 ins., 82 ft. 8 ins., 62 ft., and three new columns supporting same; supply of complete new floor system; supply of new rollers, shoes, bed plates, etc., for present trusses, erection and painting. Specifications, etc., at the office of the City Engineer, Toronto.

Buildings.

Bids are asked on following work, the notes being arranged alphabetically by states:

Wilmington, Del.—Until 10 a. m., June 1, by the Light House Engineer, for erecting three dwellings, one at Delaware Breakwater, range Rear Light Station, Delaware; one at Assateague Light Station, Virginia, and one at Bellevue Range Rear Light Station, Delaware.

Fernandina, Fla.—Until 3 p. m., June 7, by James Knox Taylor, Supervising Architect, Washington D. C., for the construction, complete, of the U. S. Post Office and Custom House at Fernandina.

Chicago, Ill.—Until 11 a. m., May 20, by Department Public Works, for marble and tile work in public bath house to be located at 822 W. 20th St.

Chicago, Ill.—Until 11 a. m., May 20, by Department Public Works, for constructing shelter platforms, etc., at Wrightwood Ave. and Perry St. playgrounds.

Mayfield, Ky.—Until 3 p. m., June 15, by James Knox Taylor, Supervising Architect, Washington, D. C., for the construction, complete, of the U. S. Post Office at Mayfield.

Alexandria, La.—Until June 15, by D. B. Showalter, Parish Superintendent, for the erection of a two-story and basement brick school building, estimated to cost $45,000, for Rapidew Parish.

Boston, Mass.—Until 11 a. m., May 24, by Col. F. L. Denny, Q. M., U. S. Marine Corps, Washington, D. C., for the completion of the marine barracks, Navy Yard, Boston, Mass.

Fort Andrews, Mass.—Until June 3, by Capt. R. M. Rolfe, Constructing Q. M., 263 Summer St., Boston, Mass., for the construction, including plumbing, heating and electric wiring of one brick guardhouse, brick quarters for 4 officers, brick quarters for field officer, at Fort Andrews, Peddock Island, Boston Harbor, Mass.

White Earth, Minn.—Until 2 p. m., May 25, by the Commissioner of Indian Affairs, Washington, D. C., for materials and labor for the construction of three day school buildings at White Earth Agency. Further information can be obtained from the Superintendent, White Earth Agency.

Fort Wm. H. Harrison, Mont.—Until 10 a. m., May 24, by Capt. F. C. Bolles, Constructing Q. M., for construction of an ordnance storehouse (magazine).

Canton, N. Y.—Until noon, June 1, by the Chief of the Weather Bureau, Washington, D. C., for erection of a two-story and cellar brick building for the Weather Bureau at Canton.

New York, N. Y.—Until 3 p. m., May 27, by James Knox Taylor, Supervising Architect, Washington, D. C., for the foundation, track columns and basement floor of the new U. S. Post Office building in New York. McKim, Mead & White, Architects, 160 5th Ave., New York.

Columbus, O.—Until May 21, by Carl A. Steele, Secretary, for material and labor for the erection of an addition to the power house at the Ohio State University. Herbert Edwards, Architect, Columbus, O.

Columbus Barracks, O.—Until 10 a. m., May 26, by Capt. H. J. Hirsch, Constructing Q. M., for the construction of an administration building, a recruit receiving barrack, a barrack for 300 men, and a fire station, at this post, including plumbing, heating, electric wiring, and electric lighting fixtures.

Fort Sill, Okla.—Until 10 a. m., June 10, by the Constructing Quartermaster, for the construction, plumbing and wiring of the following buildings: One colonel's quarters, two field officers' quarters, seven double officers' quarters, three four-set officers' quarters, six field artillery barracks, one band barrack, four double sets N. C. O. quarters, one administration building, one post exchange, two storehouses, one bakery, six battery stables, one band stable, one Q. M. stable, three double stable, guard and shop buildings, six gun sheds, two hay sheds, one granary, one coal shed, one wagon shed, one pump house.

Carrick, Pa.—Bids are asked by Frank M. Sankey, Secretary School Board, 2727 Church Ave., Carrick (Mt. Oliver Station), for erecting a 6-room addition to the Roosevelt school building. Edwin V. Denick, Architect, House Bldg., Pittsburg.

Harrisburg, Pa.—Until noon, May 14, for Charles A. Disbrow, President Park Commissioners, 84 Union Trust Bldg., for constructing boat house at upper end of Wildwood Lake.

Fort Crockett (Galveston), Tex.—Until 2 p. m., May 31, by Capt. P. Whitworth, Constructing Q. M., Fort Crockett, Galveston, Tex., for the construction, plumbing, heating and electric wiring of 25 reinforced concrete buildings at this post.

Clifton Forge, Va.—Until 3 p. m., June 9, by James Knox Taylor, Supervising Architect, Washington, D. C., for the construction, including plumbing, gas piping, heating apparatus, electric conduits and wiring, of the U. S. Post Office at Clifton Forge.

National Soldiers' Home, Va.—Until 1:30 p. m., May 17, by John T. Hume, Treasurer, N. H. D. V. S., National Soldiers' Home, for material and labor for steel ceilings, barracks, Cos. E, M, N and O.

Orange, Va.—Until noon, May 18, by County Supervisors, C. W. Woolfork, Clerk, for remodeling Court House building.

Victoria, B. C.—Until May 31, by Evered Criddle, Supervising Architect, Public Works Department, Victoria, for (1) the erection and completion of a reinforced concrete and brick building; (2) for the erection and part completion of a reinforced concrete and brick building.

Roads and Streets.

Bids are asked on following work, the notes being arranged alphabetically by states:

Washington, D. C.—Until noon, May 15, by District Commissioners, for paving various streets and avenues with sheet asphalt.

Washington, D. C.—Until noon, May 15, by the District Commissioners, Room 427, District Bldg., for laying asphalt block pavements.

Pensacola, Fla.—Until noon, June 1, by R. M. Bushnell, Chairman Bond Trustees, for grading, paving and curbing. The work consists of approximately 170,700 sq. yds. of clay or shale blocks, sheet asphalt, bitulithic, wood block or macadam pavement, and 115,950 lin. ft. of concrete curb. . Amount of each class to be determined after proposals are received and considered. T. Chalkley Hatton, Engineer, Wilmington, Del.

Wellington, Kan.—Until May 17, by City Clerk, for paving on Washington Ave. and Harvey Ave.

Georgetown, Ky.—Until May 15, by J. W. Duncan, President County Road Committee, for grading and macadamizing 1½ miles of the Craig Road.

Chicago, Ill.—Until 11 a. m., May 19, by Board Local Improvements, C. A. V. Standish, Secretary, for paving Loomis St. from West 21st to West 22d St. with granite blocks on concrete.

Liberty, Ind.—Until 2 p. m., June 7, by Clinton Gardner, County Auditor, for constructing gravel road in Center Township and gravel road in Union Township.

Rushville, Ind.—Until 10 a. m., May 25, by J. M. Stone, County Auditor, for constructing gravel road in Richland Township.

Rushville, Ind.—Until 2 p. m., June 10 (readvertisement), by J. M. Stone, County Auditor, for constructing macadam road on line between Rush and Fayette counties. Bids for this work were opened on May 6, but work was readvertised.

Vincennes, Ind.—Until 2 p. m., June 8, by John T. Scott, County Auditor, for constructing 13,900 ft. of gravel roads in Steele Township and 11,07[illegible] ft. of gravel roads in Johnson Township.

Owosso, Mich.—Until 8 p. m., May 17, by Common Council for material and labor for paving Main St. bridge (973 sq. yds.) with white oak planking, creosoted blocks or paving brick.

Fort Snelling, Minn.—Until 11 a. m., May 27, by Capt. R. C. Croxton, Constructing Q. M., Army Bldg., St. Paul, for the construction of road and grading in connection with new stables now being constructed at Fort Snelling.

Fulton, Mo.—Until June 2, by P. D. Thurmond, City Engineer, for 7,600 sq. yds. macadam and 1,600 ft. granitoid curb and gutter, including 1,000 cu. yds. excavation. Official advertisement will be found elsewhere in this issue.

Albany, N. Y.—Until 2 p. m., May 17, by Board of Contract and Supply, Isidore Wachsman, Secretary, for following work: Grading, curbing and paving with vitrified blocks on Clinton Ave. (bond for $14,000 with bid); grading, setting granite curb and paving with vitrified blocks on Main Ave. (bond for $8,000 required with bid); excavating, filling and forming Mercer St. (bond for $800 required with bid).

New York, N. Y.—Until 11 a. m., May 17, by the Commissioners of the Common Lands Fund of the late Town of Gravesend, at the office of George B. McClellan, Mayor, for regulating and macadamizing the roadway of East 11th St. from Kings Highway to Ave. U to a width of 16 ft.

Troy, N. Y.—Until May 18, by Board Public Works, for paving 15th St. from Peoples Ave. to Congress St.

Cleveland, O.—Until 11 a. m., May 24, by William F. Eirick, Clerk County Commissioners, for the grading, draining and improving of Center Ridge Road from Wooster Road in Rocky River Township to the west line of Rocky River Township in Rocky River Township. Certified check for $1,000 required with bid.

Norwalk, O.—Until noon, May 18, by County Commissioners, for grading and macadamizing 1.8 miles of road in Norwich, Sherman and Peru Townships. Estimated cost is $1[illegible],700. Plans, etc., with County Commissioners and with James C. Wonders, State Highway Commissioner, Columbus, O.

St. Clairsville, O.—Until noon, May 2[illegible], by O. B. May, Village Clerk, for labor and material for grading, draining, curbing and paving with brick or blocks eight different streets for an aggregate length of 8,000 ft.

Steubenville, O.—Until noon, May [illegible], by County Commissioners, for grading and macadamizing [illegible] miles of road in Cross Creek Township. Estimated cost is $[illegible]. Plans, etc., with County Commissioners and with James C. Wonders, State Highway Commissioner, Columbus, O.

McAlester, Okla.—Until 7:30 p. m., May 2[illegible], by J. M. [illegible], City Clerk, for construction of vitrified brick pavement and concrete curb and gutter at an estimated cost of $[illegible]. The work includes [illegible] pavement, [illegible] curb and gutter, [illegible] ft. 12-in. [illegible] cu. yds. excavation. [illegible], City Engineer.

Coraopolis, Pa.—Until 8 p. m., May 1[illegible], by President Borough Council, for grading, curbing and paving portions of 4th Ave., Chestnut St. and Mulberry St. [illegible] Chester & Co., Engineers, [illegible] Bldg., Pittsburg.

Scottdale, Pa.—Until 8 p. m., May 2[illegible], by F. M. Newmeyer, Secretary, for grading, curbing and paving Market St. The work includes 1,200 sq. yds. [illegible] ft. curbing with [illegible] backing [illegible] vitrified brick or block [illegible] paving with [illegible] brick or [illegible]. J. B. Hogg, Borough Engineer, Connellsville, Pa. Official advertisement will be found elsewhere in this issue.

Jackson, Tenn.—Until June 1, by Atwell Thompson, City Engineer, for work in Improvement District No. 6, the work including 6,796 sq. ft. concrete walks, 6,178 lin. ft. curb and gutter, 1,426 lin. ft. 6-in. vitrified sewer pipe, [illegible] lin. ft. porous tile, etc.

Fort Monroe, Va.—Until 10 a. m., May 25, by Capt. Ernest R. Tilton, Constructing Q. M., for filling, grading, surfacing and constructing concrete walks, brick gutters and macadam roads around new buildings at Fort Monroe.

Roanoke, Va.—Until noon, May 17, by R. H. Wills, City Clerk, for paving portions of two streets.

Milwaukee, Wis.—Until 10:30 a. m., May 13, by Board Public Works, Charles J. Poetsch, Chairman, for constructing cement sidewalks and cement curb and gutter on 22d Ave. Certified check for $150 required with bid.

Milwaukee, Wis.—Until 10:30 a. m., May 13, by Board Public Works, Charles J. Poetsch, Chairman, for grading and macadamizing the roadway and grading the sidewalks on the east ½ of 22d Ave. Certified check for $200 required with bid.

Sewers.

Bids are asked on following work, the notes being arranged alphabetically by states:

Chicago, Ill.—Until 11 a. m., May 19, by Board Local Improvements, C. A. V. Standish, Secretary, for 11 contracts for constructing tile pipe sewers.

Clear Lake, Ia.—Until 3 p. m., May 17, by J. C. Davenport, Town Clerk, for constructing a sanitary sewer system, including a septic tank. The work includes 21,181 ft. of vitrified pipe sewer. Burns & McDonnell, Engineers, Scarritt Bldg., Kansas City, Mo.

Angola, Ind.—Until 7:30 p. m., May 21, by Roy Hirst, City Clerk, for the construction of a main sewer and a disposal plant.

Evansville, Ind.—Until 10 a. m., May 17, by Department Public Works, Walter F. Wunderlich, Clerk, for constructing local sewer in Jackson Ave. and local sewer in Taylor Ave.

Louisville, Ky.—Until noon, May 11, by Sewerage Commissioners, J. B. F. Breed, Chief Engineer, for Contracts No. 38 and No. 39. The work will consist mainly of building about 1,800 ft. of concrete and pipe sewers, 24 ins. and 18 ins. in diameter, and including about 200 cu. yds. of concrete.

Albert Lea, Minn.—Until June 10, by Wm. Patrick, City Engineer, for constructing of pipe and brick or concrete sewer, the work including 2,19[illegible] lin. ft. 15-in. pipe sewer, 110 lin. ft. 40-in. by 48-in. reinforced concrete sewer, 243½ lin. ft. 17-in. by 18-in. horseshoe-shaped sewer, 114 lin. ft. 12-in., 26-in. by 48-in. egg-shaped sewer, 167 lin. ft. 12-in. and 32-in. by 44-in. egg-shaped sewer. Concrete outlet, concrete intake, inverted siphon, sewage lift pump, 9 manholes, etc.

Albany, N. Y.—Until 2 p. m., May 17, by Board of Contract and Supply, Isidore Wachsman, Secretary, for constructing 12-in. vitrified pipe sewer in Jay St. Bond for $100 required with bid.

Brooklyn, N. Y.—Until 11 a. m., May 17, by Bird S. Coler, Borough President, for constructing several sewers.

Youngstown, O.—Until noon, May 1[illegible], by Board Public Service, W. H. McMillin, Clerk, for sewering Jarrett St. Bond for $[illegible] required with bid.

Wadsworth, O.—Until noon, May 28, by Village Clerk, for constructing about six miles of sanitary sewer.

Seattle, Wash.—Until May 2[illegible], by Board Public Works, R. H. Thomson, City Engineer, for constructing [illegible] sewer, extending from University grounds to [illegible] River. Estimated cost is about $[illegible].

Columbus, Wis.—Until 2 p. m., May [illegible], by H. J. W[illegible], City Clerk, for constructing sanitary sewers [illegible] ft. [illegible] lin. ft. [illegible] 8 manholes and [illegible].

Toronto, Ont.—Until [illegible], by Mayor [illegible], Chairman Board of Control, for the construction of Section No. 1 of the High Level Interceptor. The work includes [illegible] ft. [illegible] sewer [illegible] ft. [illegible] 6 ft. diameter, 14 lin. ft. of [illegible]. The work includes the building of connections with intercepting sewer, siphons, manholes, etc. Official advertisement will be found elsewhere in this issue.

St. Thomas, Ont.—Until noon, May 18, by Jas. A. Bell, City Engineer, for constructing a sewage disposal plant.

Water Supply.

Bids are asked on following work, the notes being arranged alphabetically by states:

Clearwater, Fla.—Until June 1 (extension from Apr. 20), by Thos. J. Sheridan, City Clerk, for constructing water works and sewer system.

Chicago, Ill.—Until 11 a. m., May 19, by Board Local Improvements, C. A. V. Standish, Secretary, for 25 contracts for constructing water supply pipes and 18 contracts for water service pipes.

Silvis, Ill.—Until 10 a. m., May 27, by Board Local Improvements, George Sheeth, Secretary, for constructing standpipe of 75,000 gallons capacity. H. G. Paddock, Engineer, Moline, Ill.

Muncie, Ind.—Until May 17, by Joseph E. Davis, County Auditor, for installing compression system of water works for county buildings.

Bowling Green, Ky.—Until 10 a. m., May 20, by W. H. Phillips, City Clerk, for furnishing and installing a 1,000,000-gallon capacity filtration plant of the mechanical pressure type. [illegible] Jackson, Consulting Engineer, Mt. Pleasant, Tenn.

Concord, Mass.—Until 10 a. m., May 2[illegible], by Water and Sewer Commissioners, for building intake and laying cast iron pipe. The work includes placing 1,700 ft. of 16-in. pipe intake in pond, 6,200 ft. of 16-in. pipe through private right of way, 12,200 ft. of 16-in. pipe along State Highway, 200 ft. of 8-in. pipe, blow-offs, etc., 200 ft. of 6-in. pipe, blow-offs, etc., 200 ft. of 4-in. pipe, blow-offs, etc., rock excavation 1,500 cu. yds., Portland cement concrete 200 cu. yds. at or along pond intake, 50 cu. yds. along pipe line, setting valves and hydrants, connecting extensions with present pipe system, building gate chamber in the dam. Metcalf & Eddy, Engineers, 14 Beacon St., Boston, Mass.

Springfield, Mass.—Until 2 p. m., June 2, by Water Commissioners, E. E. Lochridge, Chief Engineer, for laying two 36-in. steel or cast iron pipes under the bed of the Connecticut River. Certified check for $2,000 required with bid. Hazen & Whipple, Consulting Engineers, [illegible] Park Ave., New York.

Albert Lea, Minn.—Until 8 p. m., May 1[illegible], by Wm. Patrick, City Engineer, for water mains as follows: [illegible] lin. ft. 8-in. water main, 1[illegible] lin. ft. 6-in. water main, 1,2[illegible] lin. ft. 4-in. water main, [illegible] 6-in. gate valves, [illegible] 4-in. gate valves.

Glen Falls, N. Y.—Until 8 p. m., May [illegible], by A. S. [illegible], City Clerk, for [illegible] earth [illegible] dam about [illegible] ft. high with concrete core wall. Bond for $[illegible] required [illegible].

East Cleveland, O.—Until noon, May 2[illegible], by [illegible] Wagner, Village Clerk, for labor and material for laying [illegible] ft. of [illegible] cast iron water pipe.

McAlester, Okla.—Until 7:30 p. m., May 2[illegible], by J. M. [illegible], City Clerk, for constructing water main extensions as follows: [illegible] water pipe [illegible] in. [illegible] water [illegible] valves [illegible] boxes [illegible] fire hydrants [illegible] lin. ft. [illegible]. Estimated cost $[illegible]. [illegible], City Engineer.

Kingston, Ont.—Until May [illegible], by [illegible], Deputy Minister of Militia and Defence, Ottawa, for the installation of a new water supply at Royal Military College.

Estevan, Sask.—Until May [illegible] (extended from May [illegible]), by L. A. [illegible], Secretary-Treasurer, for constructing a water supply system and a sewer system, comprising [illegible] ft. of water mains, [illegible] ft. of [illegible] sewer, [illegible]. Willis Chipman, Engineer, [illegible] King St. [illegible], Toronto, Ont.

Miscellaneous.

Bids are asked on following work, the notes being arranged alphabetically by states:

New Orleans, La.—Tow Boat.—Until 11 a. m., June 1, by Capt. H. B. [illegible], U. S. Engineers, [illegible] St. Charles Ave., New Orleans.

for constructing and delivering a steel hull stern-wheel tow boat.

Boston, Mass.—Street Lighting.—Until July 1, by Guy C. Emerson, Superintendent of Streets, for gas lighting streets, alleys, etc., for a period of five years.

Cleveland, O.—Timber Trestle.—Until noon, May 30, by E. H. McIntosh, Secretary Board of Public Service, for the construction and completion of a timber trestle over Kingsbury Run, from E. 65th St. to Berwick Road, S. E. Certified check for $1,000 required with bid

Wilkesbarre, Pa.—Street Lighting.—Until noon, May 20, by Fred H. Gates, City Clerk, for lighting certain streets with arc electric lights.

Fort Bliss, Tex.—Bowling Alley.—Until 10 a. m., May 15, by Constructing Q. M., for the construction of a bowling alley on the Military reservation at Fort Bliss.

Wheeling, W. Va.—Dam Work.—Until 11 a. m., June 8, by Capt. F. W. Altstaetter, U. S. Engrs., Wheeling, for constructing abutment, piers and weirs for dam No. 11, Ohio River.

Ashland, Wis.—Riprap.—Until noon, June 8, by Lt. Col. Graham D. Fitch, U. S. Engrs., Duluth, Minn., for furnishing riprap at Ashland, Wis.

Superior, Wis.—Stone and Pebbles.—Until noon, June 7, by Lt. Col. Graham D. Fitch, U. S. Engrs., Duluth, Minn., for furnishing stone and pebbles for Superior Entry, Wis.

Toronto, Ont.—Underground Conduit.—The City of Toronto will shortly call for tenders for the laying of underground conduit. For specifications, apply to the Electrical Dept., City Hall. Official advertisement will be found elsewhere in this issue.

Moose Jaw, Sask.—Sinking Test Well.—Until 8 p. m., May 31, by John D. Simpson, City Clerk, for sinking a test well for gas, oil or water. Bids are wanted for a well 2,500 ft. and 3,000 ft. deep.

Excavation, Earth and Rock.

Bids are asked on following work, the notes being arranged alphabetically by states:

San Diego, Cal.—Dredging.—Until 11 a. m., June 4, by Capt. Amos A. Fries, U. S. Egrs., 723 Central Bldg., Los Angeles, for dredging at San Diego Harbor.

Washington, Barracks, D. C.—Filling.—Until noon, May 22, by H. L. Pettus, Constructing Quartermaster, Takoma Substation, Washington, D. C., for furnishing and delivering earth for filling at Washington Barracks, D. C., either by hydraulic dredge or hauling.

Valparaiso, Ind.—Ditch.—Until 1 p. m., May 22, by Geo. Haxton, Construction Commissioner, at the office of Johnston & Bartholomew, Valparaiso, Ind., for the Robbins Ditch, the work including 40,144 cu. yds. open ditch, suitable for dry land excavators; also for 8,095 lin. ft. drain tile 10-in. to 18-in. Estimated cost is $6,200.

Baltimore, Md.—Dredging.—Until 1 p. m., June 7, by Maj. W. E. Craighill, U. S. Engrs., Room 309, Custom House, Baltimore, Md., for dredging in Claiborne Harbor, Elk, Chester, Warwick, La Trappe, Wicomico and Pocomoke Rivers, Md., Nanticoke River, Del. and Md., and Broad Creek River, Del.

Redwood Falls, Minn.—Ditch Work.—Until 2 p. m., May 27, by L. P. Larson, County Auditor, for constructing Judicial Ditch No. 5, the work including 12,600 ft. of plow ditch 3 ft. deep, 7 ft. wide on top and 18 ins. wide on bottom; also 45,500 ft. of plow ditch 5 ft. deep, 10 ft. wide on top and 2 ft. wide on bottom; estimated cost of plow work is $7,053; also 20,525 cu. yds. of scraper excavation, estimated cost of which is $3,078; also 809 rods, average cut 14 ins., hand shoveling in bottom of plow ditch.

Kenton, O.—Dredging.—Until 10 a. m., May 24, by James C. Paling, County Engineer, for dredging of Lower Scioto River Improvement No. 123. Estimated cost $6,000.

Fort Moultrie, S. C.—Dredging.—Until noon, May 31, by the Constructing Q. M., for dredging channel from quartermaster's wharf, Fort Moultrie, to Charleston Harbor, S. C.

Guayama, P. R.—Irrigation Work.—Until 2 p. m., June 14, by B. M. Hall, Chief Engineer Porto Rico Irrigation Service, for the construction of about 24 miles of main canal with appurtenant structures, including four tunnels and five reinforced concrete siphons. The estimated cost is about $155,000. Plans, etc., may be obtained from Mr. Hall or from the Commissioner of the Interior, San Juan, Porto Rico, or from the U. S. Reclamation Service, Washington, D. C. Official advertisement will be found elsewhere in this issue.

Materials, Machines, Supplies, Etc.

Bids are asked on following work, the notes being arranged alphabetically by states:

Mobile, Ala.—Asphalt Repair Plant.—Board Public Works, Wright Smith, Chief Engineer, wants small asphalt mixing repair plant of capacity of about 250 yds. per day.

Washington, D. C.—Lathes, Tools.—Until 2 p.m., May 21, by James Wilson, Secretary of Agriculture, for furnishing and delivering lathes and other shop tools.

Washington, D. C.—Cranes, Buckets, Etc.—Until 10:30 a. m., May 24, by Capt. F. C. Boggs, General Purchasing Officer, Isthmian Canal Commission, for furnishing under Circular 508 locomotive cranes, orange peel buckets, pneumatic hoists, duplex pumps, pipe-threading machine, woodworking machines, flanging clamps, driving wheel jacks, washer cutters, belt punches, malleable iron castings, steel forgings, chain, steam and vacuum gages, park benches, lumber, etc., fire clay, asbestos cement, etc.

Key West, Fla.—Conveyor System.—Until 11 a. m., June 5, by Bureau Yards and Docks, Navy Department, Washington, D. C., for a coal conveyor system of the gravity bucket type at the U. S. Naval Station, Key West.

Atlanta, Ga.—Cement Testing Apparatus.—Until 10 a. m., May 31, by R. V. LaDow, Superintendent of Prisons and Prisoners, Washington, D. C., for furnishing and delivering at U. S. Penitentiary at Atlanta, a cement testing apparatus.

Baltimore, Md.—Grass Destroyer.—Until 11 a. m., May 19, by J. L. Wickes, Commissioner of Street Cleaning, for furnishing the department of street cleaning with a preparation for destroying grass and weeds.

Bemidji, Minn.—Fire Hose.—Until 8 p. m., May 24, by Thos. Maloy, City Clerk, for 1,000 ft. of 2½-in. triple-jacket fixtures.

Fort Totten, N. Y.—Automatic Anchors.—Until noon, June 1 (postponement from Apr. 15), by Capt. J. A. Shipton, Disbursing Officer, U. S. Torpedo Depot, for supplying automatic anchors.

Yonkers, N. Y.—Engine, Dynamos, Etc.—Until 8 p. m., May 17, by James D. McIntyre, Secretary Board Contract and Supply, for the furnishing and delivering f. o. b. Yonkers, of one engine, to be connected direct with dynamo, of standard make and guaranteed to supply 7-kilowat power, with a voltage of 115. Also a submerged centrifugal pump connected direct to a standard motor; the pump and motor to be first-class in every respect, and fully equipped with all necessary auxiliaries.

Brownsville, Pa.—Air Compressor Plant.—Until noon, June 9, by Maj. H. C. Newcomer, U. S. Engrs., Pittsburg, Pa., for furnishing and installing a water power and compressor plant at New Lock 5, Monongahela River, Brownsville.

Philadelphia, Pa.—Freight Elevator.—Until 11 a. m., May 17, by Col. F. L. Denny, Q. M., U. S. Marine Corps, Washington, D. C., for furnishing and installing complete at the Depot of Supplies, 1100 South Broad St., Philadelphia, one electric freight elevator.

Pittsburg, Pa.—Motor Cycle.—Until noon, May 17, by R. J. Cunningham, County Controller, for one motor cycle for office of County Engineer.

Madison, S. Dak.—Gas and Electrical Equipment.—Until 8 p. m., May 12, by Wm. Rae, City Auditor, for furnishing producer gas and electrical equipment.

Fort Monroe, Va.—Screens.—Until 10 a. m., May 27, by Capt. Ernest R. Tilton, Constructing Q. M., for wire door and window screens for 15 new buildings at Fort Monroe.

Seattle, Wash.—Metal Shelving.—Until 3 p. m., May 19, by James Knox Taylor, Supervising Architect, Washington, D. C., for metal vault shelving for the U. S. Court House, Custom House and Post Office at Seattle.

Manila, P. I.—Gate Valves, Hydrants.—Until noon, July 1, by H. L. Fisher, Secretary of the Municipal Board, Manila, P. I., for furnishing gate valves, air valves and fire hydrants for the city of Manila, Philippine Islands. The total amount to be furnished will be 160 gate valves, 20 air valves and 325 fire hydrants.

Pretoria, Transvaal.—Drills.—Until noon, July 9, by James R. Leish, Chairman of the Tender Board, P. O. Box 376, or Room No. 53, Law Courts Bldg., Pretoria, Transvaal, for portable non-traction percussion rope drilling machines capable of drilling a hole of 6 ins. diameter to a depth of 1,000 ft. for the Department of Land and Irrigation.

CONTRACTS LET.

The following contracts have been let recently:

BRIDGES.

Savannah, Ga.—Bridge.—Gadsden Contracting Co., Savannah, Ga., at $6,500, for constructing Dundee Canal Outlet lock and bridge of reinforced concrete.

Des Moines, Ia.—Concrete Amphitheater.—Des Moines Bridge & Iron Co., at $78,906 for constructing a steel and concrete amphitheater on State Fair Grounds.

New Hampton, Ia.—Councrete Bridges.—M. N. Stark & Co., Des Moines, Ia., at $6,558, for constructing 16 concrete bridges, for county.

Rock Falls, Ill.—Bridge.—John P. Harvey, Amboy, Ill., at $1,225, for constructing bridge across the ditch one-half mile west of Zion Church.

Goshen, Ind.—Bridges.—Contracts for county bridges have been let as follows: Elkhart Bridge & Iron Co., Elkhart, Ind., three bridges, total $20,180; D. D. Lehman, Middlebury, Ind., five bridges, total $2,875; Van Skyhawk & Kitch, Bremen, Ind., two bridges $1,695.

Lebanon, Ind.—Bridges.—Geo. T. Miller at $317 and $129 and $129 for construction of 3 bridges; D. W. Bokannon at $345 for 1 bridge; D. P Turner at $468 for 1 bridge; Shahan & McCarthy at $280 for 1 bridge; John Adams at $238 for 1 bridge. Companies all of Lebanon, Ind. Work to be done for county.

Newport, Ind.—Steel Bridges.—Lafayette Engineering Co., Lafayette, Ind., at $4,168, for constructing two 64 ft. span steel bridges with concrete floor and substructure; Attica Bridge Co., Attica, Ind., at $925, on one 54 ft. steel superstructure with concrete floors; John O. Wright, Clinton, Ind., at $723 if no piling is used and $925 if piling, for substructure.

Clearwater, Kan.—Bridge Repairs.—Wichita Construction Co., Wichita, Kan., at $1,925, for repair work on the bridge over the Minnescah River two miles west of this place for county.

Newton, Kan.—Pile and Steel Bridges.—County Commissioners of Harvey County have awarded the following bridge contracts: Pile bridge 76 ft. long, 16-ft. roadway, B. H. Northcott, for $450; pile bridge 61 ft. long, 14-ft. roadway, between Sections 29 and 32, Richland Twp., A. L. Lewellen, for $273; deck of this bridge to be of lumber from old bridge; steel bridge 156 ft. long, 16-ft. roadway, with concrete floor, across Little River in Halstead Twp., Illinois Steel Bridge Co., Hughes & Hammond of Kansas City as agents, for $2,525.

Paducah, Ky. — Bridges. — Vincennes Bridge Co., Vincennes, Ind., for construction of Clark's River bridge, including 300 ft. reinforced concrete bridge and 120-ft. steel span; Vincennes Bridge Co., at $3,300 for constructing bridge across Perkins Creek.

Ann Arbor, Mich. — Bridge Work.—Toledo-Massillon Bridge Co., Toledo, O., to supply the structural iron for bridge improvements on the Ann Arbor Railroad. The principal steel bridge structure will be over the Huron River at Ann Arbor. This bridge will consist of nine span girders, six of them 80 ft long, one 50 ft. long, one 46 ft. long and one 24 ft. long. The total length of the bridge will be 104 ft. The other structure will be a 104-ft. trestled truss bridge over the Schawossa River at Byron, near Owosso. The construction of the latter bridge is already under way, and work will be begun on the Huron River bridge in a short time.

Magnolia, Miss.—Steel Bridge.—Vincennes Bridge Co., Vincennes, Ind., at $2,990, for constructing steel bridge (one 100 ft. steel span and two 50 ft. spans) at Holmesville, for county.

London, O.—Bridges.—Mt. Vernon Bridge Co., at $8,983, for superstructure two 120 ft., 18 ft. riveted 24 ft. trusses and concrete floor slab with cresoted block paving; Winchell & McDaniel, at $5,219, substructure for Big Darby creek bridge, Post Road.

Portsmouth, O.—Masonry Abutements.—J. A. Davis, Otway, O., at $3.85 per cu. yd. for stone abutments and excavating for two bridges.

Newkirk, Okla.—Bridges.—Illinois Bridge Co., at $24,985, for constructing bridge over Arkansas River east of Newkirk. Missouri Valley Co., at $24,200, for bridge over Arkansas east of Ponca City. Topeka Bridge & Iron Co., at $10,500, for bridge across Chicaskia near Nardin, for county.

Allentown, Pa.—Bridges.—D. L. Emanuel, for excavating for and building new concrete piers for new iron bridge over Catasauqua Creek at Church St. for East Catasauqua Land Improvement Co.

Allentown, Pa.—Bridge—Union Bridge & Construction Co., New York City, at $1 [illegible] for construction of reinforced concrete bridge over Brushy Meadow Creek over Washington St. in the Borough of Bangor.

Rock Hill, S. C.—Steel Bridge—Roanoke Bridge Co., Roanoke, Va., at $[illegible] for [illegible] ft. steel span and [illegible] ft. wood approach.

Nashville, Tenn.—Bridge and Trestle Work—C. B. Walker, Nashville, for [illegible] the steel bridge and trestle work on the Middle Tennessee R. R., which is to be built from Franklin to Leatherwood. This work will include the construction of twenty-five or thirty bridges and trestles.

Fond du Lac, Wis.—Bridges—[illegible] Wausau Iron Works, Wausau, Wis., for construction of two-span bridges.

Sheboygan, Wis.—Bascule Bridge—Milwaukee Bridge Co., Milwaukee, Wis., at $[illegible] 240 for constructing new bascule bridge for this city at Pennsylvania Ave.

ROADS AND STREETS.

Santa Barbara, Cal.—Road Work—Pattillo Contracting Co., at $46,000, for improving roads in permanent road division of Montecito, including Road No. 1, Coast Highway, city limits to foot Ortega Hill, 2, Hot Springs Ave., city limits to Valley Road, [illegible], Knowles corner to Pasa Grande Lane, 4, San Ysidro Road, Coast Highway to Valley Road, 5, Sycamore Canon Road, Hot Springs Ave. to Wade corner, grading and paving about 6.16 miles of road.

Gainesville, Ga.—Brick Paving—Georgia Engineering Co., Augusta, Ga., at $1.84 per sq. yd. for paving streets with 17,000 yds. vitrified brick.

Brazil, Ind.—Gravel Roads—Hawkins Bros., Brazil, at $7,814 for constructing Brothers gravel road in Harrison Township. Crabb & Campbell, Brazil, Ind., at $[illegible] 47 for constructing Roma gravel road in Perry and Jackson Townships.

Brownstown, Ind.—Gravel Roads.—J. V. Hinderlelder, Medora, Ind., at $1,011, for constructing two gravel roads. James [illegible], Seymour, Ind., at $4,114, for constructing 1 gravel road for county.

Delphi, Ind.—Roads—J. F. Pierce, Delphi, Ind., for constructing three gravel roads; Walter Gerten, Logansport, Ind., for constructing one gravel road, for county.

Decatur, Ind.—Roads—W. V. Buckmaster, Geneva, Ind., at $3,6[illegible] for macadamizing Mt. Zion road. Wheat & Sisk, Bryant, Ind., at $[illegible] for macadamizing Teeple road.

Franklin, Ind.—Gravel Roads—John W. Murphy, R. R. 18, Greenwood, Ind., at $3,8[illegible], for constructing two gravel roads of a total length of three miles.

Fowler, Ind.—Road Work.—Haynes & Sims at $16,4[illegible] for constructing six miles of stone road on county line between Benton and Jasper counties.

Greencastle, Ind.—Macadam Roads—Carter & Vincent, Bainbridge, Ind., at $[illegible] and $10,3[illegible], for constructing macadam roads, three miles in Greencastle and Monroe Townships and 1½ miles in Marion Township, Putnam County, Ind.

Monticello, Ind.—Gravel Road—M. J. Harwood, at $[illegible] for constructing H. N. Shook Road, including three miles gravel road and one [illegible] ft. iron bridge.

Newport, Ind.—Grading—[illegible], Terre Haute, Ind., at [illegible] per cu. yd. for constructing grade west of Cayuga Bridge for county. The work includes building a grade about 1½ miles long, average height about [illegible] ft., containing about [illegible] cu. yds. of dirt.

Paoli, Ind.—Macadam Road—O. D. Sorley, Orleans, Ind., at $1,[illegible] for constructing gravel road.

Peoria, Ill.—Paving—J. S. [illegible] & Co., at $3,[illegible] for paving [illegible] South [illegible] St. John McAllister, at $[illegible] for paving [illegible].

Terre Haute, Ind.—Gravel Road—[illegible] & Reed, [illegible], Ind., at $[illegible] for construction of [illegible] Road with gravel.

Versailles, Ind.—Macadam Roads—John S. Rogers, at $11,[illegible] for grading and macadamizing four miles [illegible] ft. of macadamized road.

Versailles, Ind.—Macadam Road—Harry Demmer, at $[illegible] for grading and macadamizing 10,[illegible] ft. of road.

Winamac, Ind.—Gravel Road—Jacob F. Quigley, Knox, Ind., at $[illegible] for constructing 1 [illegible] of gravel roads for county.

Newark, N. J.—Paving Contracts—Maher & McNichols, Kearny, N. J., at $[illegible] for paving three streets in Belleville Township. Jannarone Bros., Belleville, at $[illegible] for paving Magnolia St., Anthony P. Gerber Stone Co., Newark, at $1,1[illegible] for paving Heckel St., in Belleville.

Fulton, N. Y.—Paving—Wilson & Co., [illegible], Pa., at $[illegible] 16 for brick and macadam paving.

Oneonta, N. Y.—Stone and Concrete Sidewalks—Pagels Stone Co., Oneonta, for [illegible] stone and concrete sidewalks at [illegible] 13 cts. per sq. ft. for the [illegible] ft. walks, [illegible] cts. per sq. ft. for the [illegible] ft. walks and 1[illegible] cts. per sq. ft. for the 6-ft. walks for the stone walks. On concrete walks bid was 11 cts. per sq. ft. for the walk with [illegible] foundation and 11 cts. per sq. ft. for the steel reinforced walk.

Rochester, N. Y.—Paving—Whitmore, Rauber & Vicinus at $[illegible] for paving Plymouth Ave. with asphalt. H. N. Cowles, at $18,[illegible] for macadam improvement on Lake Ave. Rochester Vulcanite Pavement Co., at $[illegible] for Brown St. asphalt and Medina block. Whitmore, Rauber & Vicinus at $[illegible] for asphalting Culver Road. Hageman, Miller & Hagaman, at $3,898 for [illegible] St. brick pavement. H. C. Schroeder at $[illegible] for resurfacing Goodman Street.

Schenectady, N. Y.—Paving—Schenectady Constructing Co., for paving, grading and curbing Wright St., at 60 cts. per cu. yd. for excavation, and $2.20 per sq. yd. for asphalt.

Ashland, O.—Macadam Road—D. A. Phillips, W. Main St., Ashland, O., at $[illegible], for five miles of macadam road, the work includes hauling, grading and furnishing material.

Cadiz, O.—Paving—Rosser & Maloney, Bellaire, O., at $16,[illegible]16 for paving streets with 8,048 sq. yds. brick, including furnishing all material and work.

Cincinnati, O.—Roads.—Wm. J. Garretson, Columbia Ave., Cincinnati, O., at $16,811 for improvement of Madisonville pike, from Oakley to Madisonville, including improvement of Crosby Ave. from Highland Ave. to Madison Road in Sycamore Township.

Cincinnati, O.—Road—Peter Plaechten, Mt. Auburn, Cincinnati, O., for constructing Polk Run Road, for county.

Cincinnati, O.—Road.—W. Taulman, Hazelwood, O., at $1,419, for improvement of road from north end near little Miami River, 1,500 ft. south in Sycamore Township.

Cincinnati, Ohio.—Paving.—The Kirchner Construction Co., West St., Cincinnati, O., for paving with wood blocks, Locust St., from Ashland Ave. to Alms Place.

Oceola, O.—Pike Roads.—Contracts for constructing pike roads for Todd Township have been let as follows: Lemert road, east, H. N. Oberlander, $2,563, Lemert road, west, H. N. Oberlander, $1,284, Lemert road, north, H. N. Oberlander, $1,118, Glen Eden road, J. C. Reiff, $1,160, Gordon road, Sousley Bros., $1,410, Oceola road, west, Sousley Bros., $2,321; Melmore-Marion road, Sousley Bros., $1,076.

Youngstown, O.—Paving.—John Grady, Youngstown, O., at $8,802 for paving of Commerce St.

Zanesville, O.—Paving Brick.—Townsend Brick & Construction Co., Zanesville, Ohio, for furnishing brick for paving parts of ten streets. Fultonham Brick Co. for one street. Robin Brick Co., Zanesville, O., for one street.

Portland, Ore.—Asphalt Paving, Etc.—Barber Asphalt Paving Co., at $171,000 for laying asphalt on Hawthorne Ave. Montague-O'Reilly Co., at $80,000 for laying Belgian blocks in North Portland.

Erie, Pa.—Paving—Mayer Bros., for grading, curbing and paving 17th St., from State to Parade St.

Kingston, Pa.—Paving—B. G. Coon, Forty Fort, at $17,2[illegible] for paving on concrete base, Wainwright steel protected curb and Clymer brick.

New Castle, Pa.—Paving—J. H. & M. E. Moore, at $[illegible] for paving [illegible] Ave. and grading of [illegible] St.

New Brighton, Pa.—Paving—J. H. & M. E. Miller, New Castle, Pa., for paving 17th St., [illegible] 1,400 sq. yds. brick, 1,000 sq. yds. [illegible] paving, 1,000 sq. yds. grading, 1,000 lin. ft. concrete curb and gutters.

Park (P. O. Knoxville), Tenn.—J. P. M[illegible], Knoxville, at $[illegible] per cu. yd. for [illegible] macadamizing for the city. Peters & [illegible], Knoxville, at $1.4[illegible] per cu. yd. for [illegible] macadamizing. The work includes about 4,[illegible] cu. yds. of macadam, each contractor taking half of the work.

Galveston, Tex.—Curbing and Sidewalks—J. C. Underwood, at $[illegible] for construction of curb and sidewalks on boulevard.

Galveston, Tex.—Paving, Curbing—Kelso & [illegible], at $[illegible] for paving [illegible] from [illegible] St. to [illegible] St. with [illegible] vitrified block and at $1.8[illegible] for [illegible] curbing.

Salt Lake City, Utah.—Street Paving Extension—J. J. Moran, Salt Lake City, at $[illegible] for paving extensions [illegible] and 40.

SEWERS AND WATER SUPPLY

Denver, Colo.—Sewers—The Denver & Pueblo Construction Co., at $24,[illegible] for constructing new sewer in [illegible] and South [illegible].

New Haven, Conn.—Water Tunnel—[illegible], 26 Broadway, New York, at $10.[illegible] per lin. ft. for [illegible] a [illegible] ft. [illegible] tunnel and at $[illegible] per lin. ft. for [illegible] ft. of lined tunnel for the New Haven Water Co.

Oak Park, Ill.—Water Mains—T. H. [illegible], [illegible], Ill., at $[illegible] for laying water mains, the work including [illegible] ft. [illegible]-in. pipe, [illegible] ft. [illegible]-in. pipe, [illegible] ft. [illegible]-in. pipe, 17 fire hydrants, [illegible] gate valves and necessary fittings.

Hammond, Ind.—Sewer—[illegible] Brothers, for constructing [illegible] St. [illegible] sewer.

Logansport, Ind.—Sewer—J. [illegible], Logansport, Ind., at [illegible] cts. per lin. ft. for constructing 1,[illegible] ft. of [illegible] sanitary sewer complete for county.

Washington, Ind.—Ditch—Chas. E. Cunningham, [illegible], Ind., at $[illegible] for constructing the Marshall Cooper Ditch.

Hutchinson, Kans.—Sewers—[illegible] Construction Co., at following bids for constructing sewer extensions: [illegible] ft. [illegible]-in. sewer at [illegible] cts. per ft.; 1,[illegible] ft. 12-in. sewer at [illegible] cts. per ft.

Carthage, Mo.—Drilling Well—P. D. Crossman, Joplin, Mo., makes following bid for drilling well 11 in. in diameter with 8¼ in. casing. The contract price is as follows: $1.35 per ft. to the bottom of the casing; after that the price will be $1.[illegible] per ft. until 1,000 ft. of depth is reached. From 1,000 ft. to 1,100 ft. the price will be $1.[illegible] per ft., with an increase of $1[illegible] per 100 ft. for each additional 100 ft. of depth after that.

Trenton, Mo.—Sewer—Skidmore Construction Co., St. Joseph, Mo., for construction of sewer in District [illegible].

Cincinnati, O.—Sewers—W. S. Hollenbeck, at $4,112 for laying sewers in Erkenbrecker Ave., Wilson Ave., Hearne and [illegible] Ave.

Mt. Gilead, O.—Sewer Disposal Plant—M. W. Shaw & Co., Marion, O., at $[illegible] for constructing sanitary sewer and disposal plant. The work includes [illegible] ft. trench under 6 ft., 1,0[illegible] 6 to 8 ft., [illegible] ft. 8 to 10 ft., 375 10 to 18 ft., 4,[illegible] ft. 8-in. pipe, 2,[illegible] ft. 10-ft. pipe, [illegible] ft. 1[illegible]-in. pipe. Disposal tank and ¼ acre of filter bed, [illegible] manholes, etc.

Hugo, Okla.—Water System—W. W. Cook & Son, Junction City, Kan., at $[illegible] for constructing complete system of water works including material, tools and labor.

Oklahoma City, Okla.—Sewers—Dorr & Wiles, for constructing sewers in [illegible] Ave., Bellevue Ave., and Cream Ridge additions.

New Castle, Pa.—Sewer—[illegible] Stapf at $714 for constructing a sanitary sewer on Vine St.

New Wilmington, Pa.—Sewer System—Marquis & Wallace, New Castle, Pa., for construction of sewer system for New Wilmington.

Philadelphia, Pa.—Main Sewers—Contracts for the construction of main sewers have been let as follows: [illegible] Run, storm water sewer extension in [illegible] St., to Edwin H. Vare for $[illegible]; [illegible] intercepting system extension, Leonardo & Pazzuzi, $[illegible]; Cumberland [illegible] extension, David McMahon, $[illegible]; Mayes St., [illegible], Coleman & Co., $[illegible]; [illegible] St., Lombardi & Perna, $[illegible]; Wingohocking extension, Robert Hughes, $[illegible]; Wyoming Ave., Lombardi & Corcoran, $[illegible].

Salt Lake City, Utah.—Water Mains.—[illegible] received [illegible] by [illegible], Public Works, L. C. Kelsey, city engineer, for constructing water mains, the contract being awarded to [illegible] Bros. & Schwartz at $[illegible], their itemized bid being as follows:

[illegible]	$ [illegible]
Cast iron pipe:	
4-in., [illegible] lin. ft.	[illegible]
[illegible]	[illegible]
[illegible] ft.	1 [illegible]
[illegible] ft.	1 [illegible]
[illegible] ft.	2 [illegible]
[illegible] ft.	2 [illegible]
Special castings, [illegible]	[illegible]
Valves:	
[illegible]	11.75
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
Hydrants, ea. [illegible]	[illegible]
Cast iron valve boxes, ea. [illegible]	[illegible]
Brick valve boxes, ea. [illegible]	25 [illegible]
[illegible] boxes, ea. [illegible]	[illegible]
Cement plaster, sq. yd. [illegible]	[illegible]

Salt Lake City, Utah.—[illegible] Tank—Zarbe & Walker at $[illegible] for constructing tank for [illegible] Ward pipe line in City Creek Canyon.

Bellingham, Wash.—Sewers.—Fred McElmon, at $14,231, for laying sewer in Eldridge Ave., from Broadway Str. to a point near Squalicum Creek and on Holly St. from G. to Broadway Sts. The main sewer west of Broadway will consist of 340 ft. of 8-in. pipe, 890 ft. of 10-in. pipe, 692 ft. of 12-in., 622 ft. of 14-in., 890 ft. of 16-in., 606 ft. of 18-in., and 780 ft. of 20-in. pipe

Burlington, Wis.—Sewer and Water Extensions.—Bids were opened by this city, P. J. Hurtgen, City Engineer, on May 3, for sewer and water main extensions, the contract being let to N. F. Reichert, at the following itemized bid: 1,239 ft. 15-in. vitrified pipe sewer, $1.00; 824 ft. 10-in. vitrified pipe sewer, $0.80; 944 ft. 12-in. vitrified storm sewer, $0.80; 3 manholes, $30; 15 catch basins, $22; 589 ft. 12-in. vitrified pipe sewer, $1.25; 523 ft. 8-in. vitrified pipe sewer, $0.90; one manhole, $35; one lamphole, $10; 2,622 ft. 6-in. water main, $0.90; 919 ft. 4-in. water main, $0.75; 7 hydrants, $15; one hydrant reset, $10; 6-in. gates and valve boxes, $15; 4-in. gates and valve boxes, $12; total, $7,615.

Janesville, Wis.—Sewers.—Mulholland & Son, at $2,780, for constructing 3,918 ft. 8 in. sewer for city.

EXCAVATION, MISCELLANEOUS, MATERIALS.

New London, Conn.—Dredging.—Hartford & New York Transportation Co., Hartford, Conn., at 11 cts. cu. yd., for dredging in Connecticut River, Conn., for U. S. Government.

Onawa, Ia.—Ditch.—John A. Brumbaugh, at 89 cts. per cu. yd., for constructing Eisele Ditch, including 57,000 cu. yds. of excavation.

Sycamore, Ill.—Drainage System.—Horton & Moseley, LaFayette Ind., at 11.48 cts. per cu. yd., for 117,260 cu. yds. excavation; Clarence Petrie, Sycamore, Ill., at $2,148, for tile ditching, including 620 ft. 24-in., 8,920 ft. 20-in., 2,000 ft. 16-in., 3,900 ft., 15-in., 5,000 ft. 12-in., 12,020 ft. 10-in., 4,360 ft. 8-in. tile drain.

Kansas City, Kans.—Levee.—Callahan Bros., Omaha, Neb., at $16,000, for constructing levee on right bank Kansas River, from West Kansas Ave. bridge to Santa Fe pumping station. Cameron, McManus & Joyce, Keokuk, Ia., at $2,000, for excavating left bank of Kansas River from K. C. Belt Line bridge and 5th St.

Paducah, Ky.—Brick Stack.—J. A. Jewell & Son, Cincinnati, O., for construction of brick stack for city lighting plant.

Louisville, Ky.—Concrete Walls, Etc.—Following bids were received May 1, by Capt. Lytle Brown, U. S. Engr., for concrete walls, etc., at lock and dam at Grand Rapids, Wabash River, (1) standing for Ohio River Contract Co., Evansville, Ind.; (2) for Ohio Concrete Co., Cincinnati, O.; (3) for Knoblock & Shelton, Erie, Pa.; (4) for Roetzel & Chipman, Evansville, Ind., and (5) for Mason & Hanger Co., Richmond, Ky.

	Quantities. cu. yds.	(1)	(2)	(3)	(4)	(5)
Concrete	1,297	$19.00	$12.25	$13.95	$11.25	$16.00
Rock excavation	nominal	1.75	3.50	3.00	3.00	3.50
Crib excavation	3,782	2.50	.78	1.34	.40	2.00
Earth excavation	2,936	1.50	.78	.64	.35	1.00
Embankment	881	1.00	.78	.55	.35	.70
Back fill	1,462	1.00	.78	.37	.20	.70
Dredging	7,000	1.00	.78	.37½	.50	.70
Stone filling (dam)	800	1.00	1.20	.97	.25	2.00
Stone filling (walls)	1,207	3.00	1.20	2.07	.55	2.50
Total	....	$52,268	$30,828	$31,968	$22,099	$42,413

Boston, Mass.—Wire Fence.—Hapgood, Frost & Co., Wellesley, Mass., at $1,600, for wire fence at Ft. Revere, Mass.

Baltimore, Md.—Use of Street Sprinklers.—P. Flannigan & Sons, Lexington and Calvert Sts., Baltimore, Md., at $405 per month, for use for city of three sprinklers from May 15 to Oct. 15. The work includes the use of sprinklers, harness, horses and driver for sprinkling with water.

Baltimore, Md.—Gravel.—Barrett Mfg. Co., at 77½c per 100 lbs., for bituminous filler; Arundel Sand & Gravel Co., at $1.50 per cu. yd., for filler gravel, and at $1.00 per cu. yd., for concrete gravel for city.

New York, N. Y.—Riprap.—Following bids were received by the Engineer of the Third Light House District:

North Dumpling, N. Y., 1,000 tons:	Per ton.
E. S. Belden & Sons, 217 Laurel St., Hartford, Conn.	$1.23
S. R. Rosoff, 13-21 Park Row, N. Y.	3.25
The T. A. Scott Co., New London, Conn.	1.49
Long Island Contg. Co	3.40
Estate of John Beattie, Lette Island, Conn.	1.42
Plum Island, N. Y., 200 tons:	
T. A. Scott Co	1.65
E. S. Belden & Sons	1.93
S. R. Rosoff	2.50
Long Island Contg. & Supply Co	2.50
Estate of John Beattie	4.30
Stratford Shoal, N. Y., 1,000 tons:	
Estate of John Beattie	1.46
E. S. Belden & Sons	1.63
S. R. Rosoff	3.00
T. A. Scott Co	1.98
Long Island Contg. & Supply Co	2.79
Romer Shoal, N. Y., 1,000 tons:	
Bouker Contg. Co., 2-24 State St., N. Y.	1.53
E. S. Belden & Sons	2.13
Estate of John Beattie	2.21
Long Island Contg. & Supply Co	2.99
S. R. Rosoff	3.00
Cedar Island, N. Y., 1,000 tons:	
Estate of John Beattie	1.45
T. A. Scott Co	1.65
E. S. Belden & Sons	1.57
Long Island Contg. & Supply Co	2.99
S. R. Rosoff	3.00
Cosackie, N. Y., 1,000 tons:	
O'Brien Bros., Inc., 54 South St., N. Y.	.95
Bouker Contg. Co.	.98
E. S. Belden & Sons	1.43
Eugene C. Sickles	1.50
Long Island Contg. & Supply Co	2.99
S. R. Rosoff	3.00
Estate of John Beattie	4.50
North Brother Island, N. Y., 1,500 tons:	
O'Brien Bros., Inc	.90
Estate of John Beattie	1.46
Bouker Contg. Co	1.47
E. S. Belden & Sons	1.47
Long Island Contg. Co	2.81
S. R. Rosoff	2.80

Boston, Mass.—Surfacing Embankment.—Bids were received Apr. 26 by the Charles River Basin Commission for surfacing Sec. 1 of Boston Embankment, the contract being let to T. H. Gill Co., Somerville, Mass., at $63,965, their itemized bid being as follows:

Removing stone block pavement, 400 sq. yds.	$ .46
Laying 8-in. vitrified pipe, 2,600 lin. ft.	.56
Laying 10-in. vitrified pipe, 3,600 lin. ft.	.64
Laying 4-in. cast iron pipe, 2,400 lin. ft.	.30
Laying 2-in. fiber conduits, 5,900 lin. ft.	.26
Service boxes "E", 6 boxes	4.50
Service boxes "F", 4 boxes	5.00
Manholes, 7 manholes	55.00
Catch basins for walks, 25 catch basins	20.00
Catch basins for roadawy, 38 catch basins	12.00
Granite edgestones in place, 1,200 lin. ft.	.99
Gravel in place in walks and roadway, 7,000 cu. yds.	1.50
Vitrified brick gutters, 1,400 sq. yds.	2.20
Broken stone in place in roadway, 2,200 tons	2.50
Granolithic walks, 4,500 sq. yds.	1.65
Loam surfacing in place, 20,000 cu. yds.	1.23

Baltimore, Md.—Timber Bulkhead.—South Baltimore Construction Co., Baltimore, Md., at about $14,000, for constructing 1,000 ft. timber bulkhead.

Sandy Hook Proving Ground, N. J.—Wood Jetties.—Jesse A. Howland, Sea Bright, N. J., at $8.15 per lin. ft., for constructing wood jetties, about 3,800 ft. in length, at the Sandy Hook Proving Ground. The work is to be completed in 100 days.

New York City, N. Y.—Cement, Riprap.—John P. Kane Co., 103 Park Ave., New York, at $1.32 per bbl., for furnishing 20,000 bbls. of cement for the Dock Department; O'Brien Bros., Inc., 54 South St., New York, at 30 cts. per cu. yd., for furnishing 40,000 cu. yds. riprap.

Columbus, O.—Building.—Ewers Brothers, for erecting new factory for Weinman Machinery Pump Co.

Altoona, Pa.—Supplies.—Contracts have been let as follows for furnishing city with supplies for ensuing year: The Altoona Brick & Tile Co., for furnishing hard brick and paving block; John Killinger, for hauling; the Good Roads Machine Co. of Pittsburg, for furnishing push brooms; J. W. Bair, of Pittsburg, inlet grates and manhole covers; R. B. Vaughn of Altoona, furnishing broken stone; Canan-Knox Supply Co., cement, sand and terra cotta sewer pipe.

Philadelphia, Pa.—Dredging. — American Dredging Co., at $9,200 or 23 cts. per cu. yd., for dredging entrance to the intake pipe at the Torresdale filter plant.

Philadelphia, Pa. — Ventilators. — Filbert Paving and Construction Co., at $7,364, for ventilators for Lardner's Point pumping station.

Fort Moultrie, S. C.—Fencing.—John F. Riley, Charleston, S. C., for erecting fence around Battery Capron.

Spokane, Wash.—Railway.—Porter Bros. & Welch, Spokane, for constructing 170 miles of railway for the Northern Pacific, from south of Mandan, N. Dak., along Missouri River to the Standing Rock and Reservation.

Wheeling, W. Va.—Excavation, Concrete, Etc.—L. G. Hallock & Son, at $31,145, for improvement of Caldwell's Run, the work including 2,000 cu. yds. excavation, 5,400 cu. yds. concrete walls and 5,700 sq. yds. of paving in bottom of Run.

PROJECTED WORK.

Bridges.

Items Arranged Alphabetically by States.

Phoenix, Ariz.—County Supervisors will probably order election in June for the construction of a bridge over the Salt River. The structure will cost about $60,000.

Pasadena, Cal.—The West Side Improvement Association, Dr. W. D. Morse, Secretary, is taking steps to secure the construction of a $15,000 concrete bridge over the railroad tracks on Columbia St.

Bonners Ferry, Idaho.—Commission has been appointed to construct a bridge over the Kootenai River at this place. The legislature has appropriated $18,000 for the bridge and $9,000 will be subscribed by citizens. James Stephenson, Jr., Boise, Idaho, is State Engineer.

Geneva, Ill.—Bids were reeeived April 28 at this city for constructing the proposed State St. bridge. George R. Keacher, Madison, Wis., at $38,983, was low bidder.

Freeport, Ill.—County Supervisors have been petitioned to construct a new bridge over Plum River in Jefferson township. The bridge will cost about $1,500.

Joliet, Ill.—The Chicago, Rock Island & Pacific R. R. has had measurements made for a new girder type bridge 67 ft. long which it is to erect over Spring Creek at Abe St.

Brownstown, Ind.—Jackson County will at once ask for bids for 12 steel bridges. J. O Wacker is County Auditor.

Indianapolis, Ind.—Ordinance has been before the council appropriating $20,000 for new bridges over the canal at 30th St., and across Emerson Run at Pleasant Ave. Bids for the 30th St. bridge were received some time ago, but contract has not yet been let.

Mt. Sterling, Ky.—Montgomery and Valley Counties are to build a joint county bridge of steel over Lulbegrud Creek on Kiddville Pike. Miller Anderson is county road supervisor.

Clinton, Me.—Town voted May 1 on making appropriation to aid in the construction of a bridge over the Kennebec River at Tishons Ferry.

Syracuse, N. Y.—State Assembly has passed bill appropriating $51,000 for the construction by the state of a new bascule bridge over the Erie Canal at North Franklin St.

Caledonia, N. Y.—Town Boards of Caledonia and Avon agree to erect a $10,000 bridge over the Genesee River on the boundary of the two towns.

Carthage, N. Y.—James R. Brownell, Village Engineer, has prepared plans for the construction of a concrete culvert and bridge on South Mechanic St.

Waverly, N. Y.—Village Board is to be petitioned to construct a reinforced concrete bridge over Dry Brook on Orange St.

Dayton, O.—County Commissioners have authorized the construction of a 150-ft. long concrete bridge over Bear Creek at Ellerton.

Cleveland, O.—Park Department has about completed plans for a $10,000 bridge to be built over Big Creek in Brookside Park. The bridge is to be built of stone masonry and will have an 81-ft. span.

Guthrie, Okla.—County Surveyor Reeves has completed plans for the proposed construction of the Noble Ave. viaduct over the Santa Fe right-of-way.

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Reinforced Concrete Caisson Breakwaters for the Great Lakes.

A new and successful form of breakwater construction recently developed on the Great Lakes is described in this issue. As engineers of marine works know, breakwater construction on the Great Lakes of North America has from the first remained wholly distinctive from ocean breakwater practice. When first the need of breakwaters at Great Lakes harbors made itself manifest the navigation interests were not large and the country was poor. The massive stone and masonry structures of the ocean works could not be built in the numbers demanded nor would they have been justified even could it have been afforded. Engineers set themselves to the task of devising a cheaper type of structure and there resulted the stone filled timber crib construction which afterwards became so common and which is yet perhaps the typical Great Lakes breakwater.

These first timber breakwaters consisted of a row of timber cribs filled with stone and capped by a timber superstructure also stone filled and decked over. The low cost of timber and the fact that in fresh water free from teredo its life was long, dictated the character of the structure. However, only the substructure, that is the stone filled cribs, could be considered as in any way permanent. The superstructure was exposed to ice, waves, rot and other destructive agencies and had to be constantly repaired and finally renewed. Of course renewal with timber simply meant repeated repairs through another term of years and finally renewal again. The increase in navigation and in wealth of the country at last urged some better solution of the problem. It was found in replacing the old timber superstructure with a solider superstructure of concrete rising from the timber cribs at a level safely below low water. The change worked well and gave a breakwater of great durability at a very reasonable cost. The new type of structure which we describe elsewhere in this issue, however, seems to be a decided improvement.

Briefly, for the old timber cribs is substituted a cellular caisson of reinforced concrete. The main structural features and the method of construction are fully described in the article referred to above and need not be detailed here. It is obvious that this new all concrete construction is more stable and permanent than that with timber cribs, but the really vital fact is that it promises also to be more economical. This point is clearly set forth in the following statement by Major W. V. Judson, U. S. Engineer Corps, under whose direction this work was done. The statement is as follows:

> Before the Algoma breakwater was commenced it was estimated that its cost if built of stone filled wooden cribs of the type commonly employed on the lakes, the piers being placed on pile foundation and capped with a standard concrete superstructure, would be [illegible] per lineal foot, and that was the cheapest way, following former practice, in which the breakwater could have been built in permanent form. The estimate for the caisson breakwater was [illegible] per lineal foot, large margins being kept for contingencies owing to the novelty of the work. The actual cost of the work proved to be but [illegible] per lineal foot, although there should be added to this, to make the estimates more comparable, [illegible] per lineal foot to allow for the salvage of riprap stone that was obtained from the [illegible] of the old north pier. It therefore appears that the saving due to the use of the caissons on the Algoma breakwater was [illegible] per lineal foot, or [illegible] per cent.

In view of the success at Algoma, Major Judson has employed the same construction at Manitowoc and later at Milwaukee. Figures on these works are not yet available.

A New Field for Engineers—Appraising Property for Purposes of Taxation.

Only to a limited extent have engineers been employed as tax assessors, yet the work of appraising values is one for which an engineer's education peculiarly fits him. Not long ago [illegible] legislator told the managing editor of Engineering-Contracting that he was contemplating drawing up a bill which would provide that all the taxable property of the state be appraised by a corps of engineers. In fact, as we recall, it was his intention to make provision for the employment of at least one engineer in every county to have charge of the tax appraisals.

An engineer is as well qualified as any other class of men to determine the value of real estate and personal property, and he is far more competent to estimate the value of structures, such as buildings, railways, telephone lines, as well as machinery and manufacturing plants of all kinds.

Considering the magnitude of the interests at stake it is rather surprising that so many untrained men have hitherto been employed to appraise property for taxation. Engineers, however, have themselves to blame for not acquainting the public with the fact that the scientific appraisal of property is an engineering problem. A little effort upon the part of local engineering societies would soon lead to legislation that would result in placing all important appraisals in the hands of engineers.

In appraising land values it may seem at first glance, that the only method available is to ascertain the prices at which tracts of similar land have been sold. While this is unquestionably the most direct and simplest method, it is not necessarily the one to be adopted exclusively. The price of land is based upon its net earning capacity. If the net earnings are ascertained the value can be closely estimated by capitalizing at a standard rate per cent. Thus, if it is known that a certain farm produces annual crops having a total gross value of $12 per acre, and if the cost of production is $6 per acre, the profit is $6, which capitalized at 10 per cent gives the land a value of $60 per acre.

Perhaps it will be many years before appraisals of land values are made in this scientific manner, but there seems to be no other way that is wholly satisfactory. The conflicting testimony of land "experts" on land values is one of the trials of an engineer's experience when engaged in appraising railway property.

That a study of costs of farming involves no slight amount of work is evident, but that such studies will become the common practice is indicated by the recent publication of a bulletin on the cost of producing farm products by the U. S. Department of Agriculture, upon which we shall make editorial comment in a subsequent issue.

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Concrete and Reinforced Concrete Section

Note:—This section is devoted to methods and cost of constructing concrete and reinforced concrete structures. It will cover the selection, testing and proportioning of concrete materials; laboratory tests of concrete; concrete mixing, transportation and placing; fabrication and placing of reinforcement, and form construction and erection. It will also contain articles on new and interesting developments in the design of reinforced concrete.

Methods and Cost of Constructing Reinforced Concrete Caisson Breakwater, Algoma Harbor, Wis., on Lake Michigan.*

BY L. E. LION.†

The river and harbor act of March 2, 1907 contained the following item: "Improving harbor at Algoma (Ahnapee), Wisconsin, by the construction of an outer harbor with a depth of 16 ft. of water, $40,000; provided that the Secretary of War may enter into a contract or contracts for such materials and work as may be necessary to complete such project, to be paid for as appropriations may from time to time be made by law, not to exceed in aggregate $100,000, exclusive of the amounts herein and heretofore appropriated."

During May and June, 1907, survey and examination, including many borings, were made on which to base a design for Algoma harbor. After considerable study of the data obtained, it was decided to build a small outer harbor in Lake Michigan, immediately south of the then existing harbor entrance, as shown by Fig. 1.

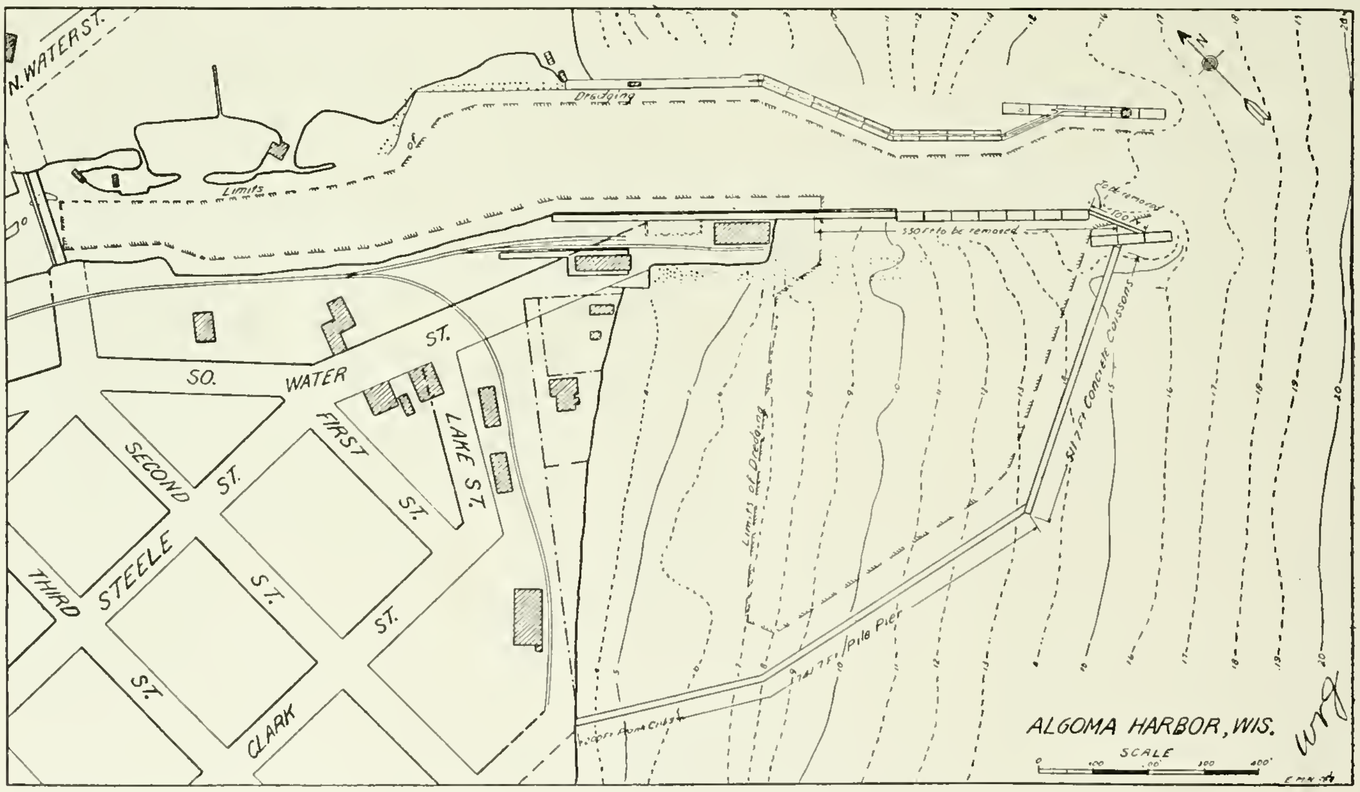

Fig. 1—Map of Algoma Harbor, Wis., Showing Location of New Breakwater.

The project embraced 511.7 lin. ft. of reinforced concrete breakwater, 733.7 lin. ft. of pile pier, 200 lin. ft. of plank cribs and about 115,000 cu. yds. of dredging. In addition, 550 lin. ft. of the old south pier were to be removed and the north pier was to be repaired by the renewal of four courses of timber in the superstructure.

The cost of this work, including supervision and contingencies, was estimated at $142,000, which was slightly in excess of the amount available, but there was a small balance on hand for maintenance, under which the repairs to the north pier properly came.

The portion of the breakwater most exposed to the action of waves consisted of 511.7 lin. ft. of reinforced concrete breakwater, made up of 20 reinforced concrete caissons 1-2-4 concrete resting on a pile foundation and surmounted by a solid concrete superstructure. Each caisson was 24 ft. in length, 15 ft. wide, and 12 ft., 4 ins. in height, with sides and end walls 12 ins. in thickness and bottom 20 ins. in thickness, 16 of which were of concrete and 4 of timber studded with 8-in. spikes. A transverse wall 10 ins. in thickness divided each caisson into two cells. The caissons were reinforced with deformed bars of the Johnson type made of mild steel and were designed to withstand water pressure from the outside while afloat and to retain the filling after being put in place. Reinforcement was also provided to give ample strength to resist the stresses of launching, handling, or unequal bearing on the foundation.

The reinforcing steel in the walls was proportioned according to the method given by Mansfield Merriman in "Mechanics of Materials," 10th edition, p. 286, the steel being assumed to carry all of the tension and compression, while the concrete was assumed to act only as a spacing medium and bear the stresses which would be carried by the web of a girder. While this method gives an excess of steel, it was thought advisable to use it on account of the early age at which the concrete would receive its launching stresses. The steel in the bottom of the caissons was proportioned according to the method given in Taylor & Thompson's "Concrete, Plain and Reinforced," 1st edition, p. 563. In order to provide for possible errors in the cutoff of foundation piles, sufficient steel was also placed in the caissons to enable them to carry safely their own weight and load due to filling, if supported only at the ends or at the center.

A foundation of 18 piles supported each caisson, the piles being cut off 11 ft. 4 ins. below datum. Riprap stone was used for filing the caissons to within 4 ft. of the top, the upper 4 ft. of the filling being of 1-5-10 concrete. In order to facilitate correct sinking, two guide timbers 12x12 ins. and 11 ft. 4 ins. long, were bolted to each end of the caissons, making an interval of 1 ft. between each caisson. This interval was afterwards filled with small stone, and capped with a slab of 1-3-5 concrete 1 ft. in thickness.

The superstructure which topped the caissons was built of 1-3-5 mass concrete, and was carried to an elevation of 4 ft. above datum. It covered 9 ft. 6 ins. of the 15 ft. of width of caissons and was approximately trapezoidal in cross-section, having a slope of 1 on 2½ on the lake side, and an almost vertical face on the harbor side. The caissons were protected by riprap on both the lake and harbor sides to within 1 ft of datum, large stone being used on the outside. A cross section of the breakwater and a horizontal section of one of the caissons are shown by Fig. 2.

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*A paper forming Appendix III of a paper by Major W. V. Judson, Corps of Engineers, U. S. A., read before the Western Society of Engineers, May 19, 1909.

†U. S. Assistant Engineer, Milwaukee, Wis.

In answer to an advertisement for proposals for building the entire breakwater, the following bids were received. All timber, except caisson bottoms and piles, together with steel reinforcing bars, were to be furnished by the United States and were therefore not included in the prices bid:

Thos. H. Smith, Sturgeon Bay, Wis., bid $[illegible] on Concrete Breakwater only.

Great Lakes Dredge & Dock Co., Chicago, Ill.	$12[illegible]
Adolph Green, Green Bay, Wis.	11[illegible]
Greiling Bros., Green Bay, Wis.	1[illegible]
Estimated cost	[illegible]
Amount available for this part of the work	[illegible]

The lowest bid was that of Greiling Bros. of Green Bay, Wis., which was $11,567 in excess of the estimated cost, and $10,057 in excess of the amount available after making due allowance for contingencies, supervision, materials to be furnished and repairs to the north pier.

All bids were therefore rejected and it was determined to execute the work by hired labor. Steps were immediately taken for the purchase of the necessary tools and materials and to begin work as soon as weather conditions permitted.

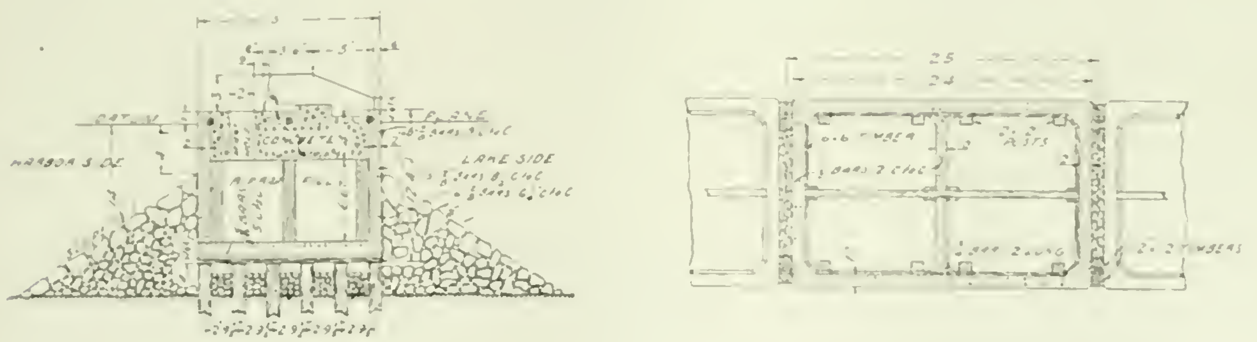

Fig. 2—Transverse Section and Plan of Algoma Breakwater.

Contracts for piles, timber and reinforcing bars had previously been entered into to supply the contractor under the proposed contract.

The United States yard at Kewaunee, Wis., was selected as the most advantageous point at which to build the reinforced concrete caissons. At Algoma, Wis., the small depth of water and rock bottom inside of the harbor would have made launching caissons hazardous, and the fact that an equal number of caissons were needed for Manitowoc, Wis., made it evident that one plant to serve both Algoma, Wis., and Manitowoc, Wis., was more advantageous to the United States than the establishment of two separate plants. Moreover, the United States owned a yard and warehouse at Kewaunee, Wis., where the construction of a permanent set of ways for hauling floating plant out of water was a desirable and necessary improvement for the maintenance of floating property. The water bordering on Government yards at Kewaunee is free from waves and currents, being on an old branch of Kewaunee River, and where the depth of water was not sufficient a small amount of dredging made it ample. Kewaunee, Wis., is 12 miles south of Algoma, Wis., and 3[illegible] miles north of Manitowoc, Wis.

Work was begun at the yard on March 12, 1908, by the erection of a warehouse for the storage of cement. As the weather moderated work was gradually extended to the launching ways and forms for the caissons. All parts of the plant were installed by June 1, 1908, when the actual construction of caissons was begun.

Launching Ways.—Three sets of launching ways were built for launching the reinforced concrete caissons. Each set of ways was 24 ft wide and 104 ft long, terminating under water at a depth of 6 ft below datum. There was a clear space of 10 ft between each set of ways. The piles supporting the ways were spaced to sustain a load of 15 tons to the pile, and were driven in bents of three piles. Each bent was capped with 12x12-in. timbers, 24 ft long. Three longitudinal timbers, 12x12 in., placed at an inclination of 1 on 10, formed each set of fixed ways. The caps were drift-bolted to the piles and the fixed ways to the caps. The gage of the ways in the clear was 22 ft. The computed weight of each caisson was 119 tons, the area of sliding ways on the fixed ways was 45 sq ft, making the load per square foot 2.65 tons.

The cost of the launching ways was $3,681.52, which includes all labor and materials.

Forms.—The forms were made in three distinct parts, the outside forms, the inside forms or core, and the trusses for holding the forms rigidly in place.

All lumber used was Oregon fir, dressed on all sides and edges. The lagging was of 2-in. boards, placed horizontally and bolted to 2x6-in. studding. Each side and end of the outside form was made in three sections to facilitate handling and placing. In the core forms each side and end was made in one piece. Struts 6x6 ins. were used inside of the core for bracing, and 20 trusses, 10 to a side, each truss stiffened with a ⅞-in. iron rod and turnbuckle for tightening, were used for stiffening the outside forms. The trusses were so built and placed that through the use of 3x12-in. boards on edge across the ends, the entire outside form was rigidly girdled and held in place. One set of trusses and bracing served the three forms.

Three sets of forms were built at a total cost of $1,8[illegible].57. After completing the Algoma caissons these forms were slightly remodeled and used in the construction of 22 Manitowoc caissons. They are still in serviceable condition.

Plant.—The launching ways previously described formed of course the most important part of the plant. In the rear of the launching ways a traveling derrick of 3 tons capacity with a 50-ft boom ran on a track of 25-ft gage parallel to the back of the ways. The derrick was so placed that it could handle the forms, steel and concrete on any one of the ways.

A number 2½ Smith concrete mixer was mounted behind the derrick so as to be readily moved by means of rollers on longitudinal timbers placed between the derrick tracks. The mixer engine received steam from the derrick boiler. In the rear of the concrete mixer and connected to the same frame as the mixer was a small auxiliary derrick which was used only for handling the broken stone and sand, which it lifted in skips from small flat cars, and dumped into a hopper immediately over and behind the mixer. This derrick was operated by a Manila line running to a winch head on the hoisting engine of the traveling derrick.

A double narrow gage track ran from the storage piles of aggregates to the mixer. The materials were shoveled into and proportioned in metal skips on flat cars. Two cars were used, one on each track, and were propelled by the men who loaded them.

A temporary warehouse for the storage of cement, 25x50 ft., was built parallel to the tracks so as to be near the mixer.

Water was supplied to the entire yard by means of a 2½ hp. gasoline engine, and a 5x5-in. double acting belt-driven force pump, which pumped the water into a galvanized iron tank mounted on a trestle over the pump house. A 2-in. water main distributed the water to the mixer, hoisting engine and other parts of the yard.

Besides the above plant a blacksmith shop, cement testing laboratory, office and warehouse for miscellaneous storage were already on the ground and were used on this work. Many small tools were also purchased for the work.

The entire cost of the plant and installation, exclusive of the cost of the launching ways and cement warehouse, was $5,778.27. The cement warehouse cost $521.10.

Setting Up Forms and Placing of Steel.—The forms were set up over the launching ways. Blocks about 12x12x6 in., which were easily split with steel wedges, were placed on the pile caps of the ways in order to secure a level support for the 12x12-in. timbers on which the bottoms and trusses were placed. Short blocks capable of being easily split with wedges were used as this was the means employed for lowering the caissons on the sliding ways at the time of launching.

After carefully leveling the timbers on which the forms was to rest, 1x12-in. timbers [illegible] through which [illegible] had previously been driven, were placed perpendicular to the supporting 12x12-in. timbers to form the bottoms of the caissons. The [illegible] handled by the derrick [illegible] the wood bottoms and the concrete

The lower layer of reinforcement was now put in place. The rods were kept above the wood bottom by small rods running perpendicular to the reinforcement and kept at the correct elevation by means of pebbles.

In later work it was found advantageous to place a layer of building paper over the wood bottoms in order to prevent the escape of mortar and cement from the concrete through the cracks in the bottom. This escape of mortar, while not great, seemed to render the bottom porous in places and caused some leaks, which, while not serious, were annoying. The use of the building paper improved the water-tightness of the bottom.

Iron brackets for supporting the core were now put in place. These were made of ⅜x1½-in. mild steel bent into the shape shown by Fig. 3. Eight of these brackets supported each core. Sixteen constituted a set, as there were two cores to a caisson. The brackets remained in the concrete.

The brackets being placed, the cores were now erected, together with their inside braces, which consisted of 80 struts of 6x6-in. Oregon fir. After the cores were erected and in proper position, beams of 4x6-in. timber were placed across the top of the cores and bolted thereto, for the purpose of suspending the wall reinforcements.

When the cores and bracing inside of the cores were in place, the upper layer of reinforcement in the bottom was put in position. This rested on bars suspended from the core braces at right angles to the direction of the reinforcement. Where the reinforcing bars crossed the supporting bars, these were wired together with No. 20 wire, so as to prevent displacement in depositing concrete.

While the bottom, core forms, and bottom steel were being put in place, the reinforcement for the walls was being prepared for the work by threading through holes punched to the proper spacing in steel flats, 1/16x2-in. By using three spacing flats for each vertical row of bars, a unit of reinforcement was formed which was readily lifted into place by the derrick and suspended from beams supported by the core. The upright reinforcing bars were wired to the horizontals before the unit was bolted in place. All of the reinforcement in the walls was put in place in this manner, except the short bars at the corners. These were wired to the horizontal bars in place.

All of the steel now being in place, the outside forming was erected, the four walls being brought up simultaneously. This forming was held in place by ten sets of trusses and boards on edge which locked around the form and held it rigidly in place and prevented yielding, as the trusses were so designed as to take up all of the pressure which was brought to the outside forms by the wet and unset concrete.

Method of Molding.—It was endeavored to mold each caisson at one continuous operation, in order to secure a perfect monolith and thus lessen the danger of leaks. All of the caissons were successfully molded at one operation, except the first one, which required two days on account of a change which was found necessary in the arrangement of the plant. No leaks developed in the caisson which was molded in two days.

A temporary platform with two hatches, one in the center of each core, was placed over the core forming. The concrete mixed to a very wet consistency was dumped through the hatches into the bottom and near the edges of the platform in molding the walls. The concrete was shoveled from the platform into the walls and puddled thoroughly by means of long sticks. Puddling of the bottom was effected by laborers working inside of the core. The bottom was placed first, and then the sides, ends and cross-walls were brought up simultaneously.

The aggregates were shoveled into skips resting on small flat cars at the stock pile. The cars were then run over the narrow gage track to the derrick in the rear of the mixer, which raised the skips and dumped them into the mixer hopper. The cement was added in the hopper. Each batch consisted of 2 bags of cement, 4 cu. ft. of crusher dust and 8 cu. ft. of 1-in. broken stone. A barrel so arranged as to measure the water used in mixing the concrete rested on the platform above the mixer and was operated by a lever by the man on the mixer platform. The concrete was given about 14 turns in the mixer and then dumped directly into a bottom dumping bucket, which was handled by the traveling derrick.

An average of 281.6 bags of cement were used in each caisson, making 1.347 bbls. of cement to every cubic yard of concrete.

As a rule, seven hours were required for molding a caisson, or 7.46 cu. yds. per hour.

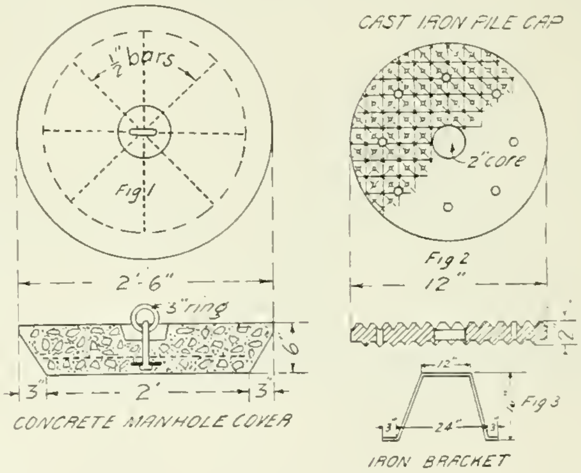

Fig. 3—Pile Cap and Manhole Cover Details, Algoma Breakwater.

The quantity and cost of materials in a caisson averaged as follows:

Stone and sand, 52.21 cu. yds., at $1.25	$ 65.26
Cement, 70.4 bbls., at $1.15	80.96
Reinforcing bars, 12,967 lbs., at 1.92 cts.	248.97
Bolts	15.59
Timber	66.65
Spikes and wire	4.54
Brackets	76.53
Flats	69.82
Total	$628.32

The force employed in molding was usually as follows:

1 Foreman at $120 per month	$ 4.00
1 Engineman at $80 per month	2.67
1 Fireman at $60 per month	2.00
1 man operating small derrick, at $2.25 per day	2.25
2 men carrying cement, at $1.75 per day	3.50
1 man on mixer platform, at $2 per day	2.00
1 man dumping mixer, at $2	2.00
6 men at stock pile and transporting aggregates, at $1.75 per day	10.50
2 men placing concrete in forms, at $2.25 per day	4.50
6 men puddling, at $1.75 per day	10.50
22 men	$43.92

This same force was employed in setting up forms, placing steel, and all other work pertaining to caisson construction.

Removal of Forms.—The inside and outside bracing were removed when the concret was 24 hours old, and the forms whenever convenient, after the concrete was 48 hours old. No difficulty was experienced in the removal of forms, nor did any material adhere to the forms so as to leave a disfigured surface, although they were not coated with any preparation.

Waterproofing.—Within two days after the removal of the forms, the outside of the caissons was given a wash of thin grout made of neat cement. This wash was applied and rubbed well into the surface of the concrete with a whitewash brush. After the cement had dried, two coats of the following wash were applied:

One pound of concentrated lye and 5 lbs. of alum were added to 2 gals. of water, care being taken that every particle was dissolved. This constituted the "stock." To 1 pint of the "stock" was added 10 lbs. of cement, and water until the mixture was of such a consistency as to spread easily on the walls with a brush. Usually 1 pint of stock was put into a 12-quart bucket, and 10 lbs. of cement stirred in with enough water added to fill the bucket. This recipe was obtained from the Report of the Chief of Engineers, 1902, Part 3, p. 2482, in which it is described by Assistant U. S. Engineer G. B. Hegardt.

With the small heads of water 9 to 10 ft. against the caissons when afloat, no difficulty was experienced in obtaining water-tight walls, and it is thought that the walls would have been impervious without the application of any preparation. As the cost of this mixture was very small, it was put on the caissons as a precaution against leakage.

All caissons were tested for leaks before applying the waterproofing wash by pumping about 6 ft. of water into each one. This was syphoned out before the application of the wash.

Launching.—Before launching, temporary timber decks were placed on the caissons for the purpose of excluding water during towing and launching. These were made in four section of 2-in. Oregon fir, with all seams tightly calked and provided with ring-bolts for lifting the sections into and fall of position. In order to shorten the span of the deck planks and add to their rigidity and supporting power, extra timbers were placed longitudinally across the inside of the caisson, so that the ties and rested on the [illegible] timbers and on the cross-walls. These timbers were supported in the middle by two [illegible] columns resting on the caisson bottom. [illegible] were used for fastening the deck to the [illegible] timbers. Two small hatches were placed in each deck for purposes of inspection. Before launching or towing the hatches were fastened down securely, and all joints around hatches and between the concrete and deck were carefully calked. A total of [illegible] for the entire work.

The 12x12-in. guide timbers shown in the drawings were bolted to the caisson ends, bolts having been embedded in the concrete for this purpose.

Three sliding shoes for launching were used under each caisson at the time of launching. These were made as shown by Fig. 4 with an oak sliding surface and Oregon fir filling pieces. The outside shoes were provided with ribbands on the inside edge. The middle shoes had no ribbands at all. The shoes were lubricated with beef tallow just before launching and then driven tightly under the caisson bottoms. An inclined shore placed against the sliding shoes in front of the caisson, together with a tripping lock on each side of the ways, held the caisson and sliding shoes in place while the weight of the caisson was being transferred from the blocks to the sliding shoes.

In order to take the load off the blocks, the small blocks supporting the 12x12-in. timbers on which the caisson rested were split with steel splitting wedges, thus allowing the caisson gradually to settle upon the ways. The small blocks having been cut out, the 12x12-in. timbers on blocks were removed and the caisson was ready for launching.

The ways having been [illegible] with tallow, men were stationed at the shores and tripping levers. At a signal previously agreed upon the shores were knocked out with sledges, and at a second signal the tripping device on each side was tripped, releasing the caisson, which started by its own weight. All of the caissons started readily as soon as released and traveled the entire length of the ways without binding in any way. The velocity of travel averaged 5.6 ft. per second.

As the ways terminated at a depth of 6 ft. below water and the draft of the caissons was about 9.7 ft., the caissons tilted and submerged themselves on leaving the ways as they had a fall of about 3.7 ft. in water. However, they righted themselves immediately and came to the surface on an even keel. Every launching was satisfactory in all respects.

A caisson having been launched, it was prepared for towing by wrapping around it a cable, to which the towing hawser was made fast.

The steel towing tug "Southern Cross" towed all of the caissons from Kewaunee, Wis., to Algoma, Wis., a distance of 11 miles from pier to pier. This boat is 78 ft. in length and of 76 gross tonnage. Her engines are 16x18-in. and her boiler carries 160 lbs. of steam.

The time of towing was usually from 6 to 7 hours, making the rate a little less than 2 miles per hour. As a rule the tug took but one caisson at a time, but on two occasions she took two at a time and handled them as well as one, although the time of towing was a little greater.

The cost of towing was $25 per caisson at first and later $20 per caisson, which included the return of the temporary decks. As the total cost of towing was $[illegible], the cost of towing per cubic yard amounted to $[illegible].

Decks.—The caissons were towed afloat to Algoma until they were needed in the work. The decks were removed by [illegible] and returned to the building yard at Kewaunee where they were used over and over. No trouble was experienced in keeping caissons afloat for weeks at a time, their imperviousness being such that no pumping whatever was required.

Breakwater Foundation.—The foundation consisted of piles driven to a firm bearing and, where practicable, to rock. Piles 30 ft. long were used and were cut off at a depth of 11 ft. 6 in. below datum.

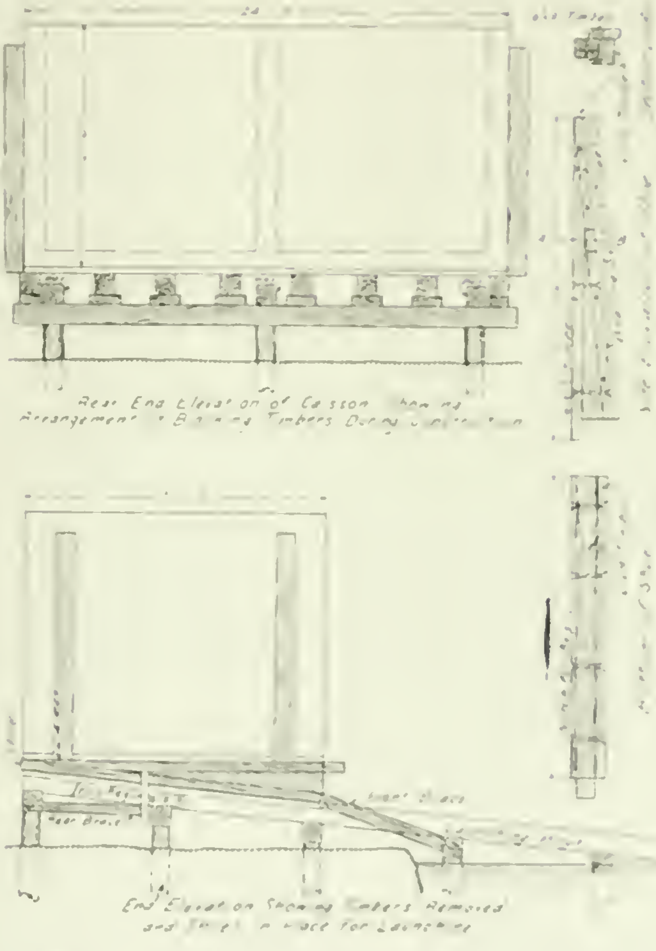
Rear End Elevation of Caisson Showing Arrangement of Blocking Timbers During Construction
End Elevation Showing Timbers Removed and Shoes in Place for Launching
Front Shoes

Fig. 4—Launching Ways and Sliding Shoes for Reinforced Concrete Caissons, Algoma Breakwater

As the piles generally stood about 3 ft. above datum when the desired resistance was attained, a penetration of about 26 ft. [illegible]. The space around the piles was filled with riprap stone, which was [illegible] about 1 [illegible] below the pile tops.

A [illegible] saw frame having [illegible] the pile being cut was used for cutting off the piles. An ordinary [illegible] saw was [illegible] the lower end of the frame and the saw [illegible] at the lower end of the saw frame. [illegible] in cutting off which were lower than the [illegible] elevation were corrected by [illegible].

to complete the leveling and [illegible] (see Fig. 5). The [illegible] and it has [illegible] found [illegible]. The [illegible] on which the [illegible] worked were made of [illegible].

Sinking and Filling Caissons.—About 150 ft. of substructure [illegible] at a time, and [illegible] were sunk. The sinking was effected by [illegible] water into the caissons [illegible]. In order to start [illegible] it was first [illegible] with water and a wooden plug having a handle was inserted in each end. The two plugs were released at the same time, and [illegible]. From 12 to 14 [illegible] were used to [illegible] sinking.

Each caisson was put into [illegible] position by [illegible] one end to the previously sunk caisson and holding the [illegible] end [illegible]. An [illegible] the position of [illegible] while being sunk and gave the [illegible]. No difficulty was experienced in [illegible]. Whenever a caisson was [illegible] placed it was [illegible] the water. [illegible] it was [illegible] 1 ft. at a time. It was [illegible].

The upper concrete filling was deposited soon after sinking. A layer of burlap was spread over the riprap to prevent mortar from running into the interstices between the stones, and the concrete placed on this. Two forms for manholes were placed in each caisson, one in each compartment, as shown in the drawing. Before concreting, the water in the caissons was pumped down below the level of the riprap, so that the filling was deposited in air. The surface of the filling was given a smooth finish where no superstructure came over it. Under the superstructure the surface was left rough so as to bind more effectively with the superstructure, which was subsequently added.

Before the caissons were sunk, 8 pile tops were placed in the caissons in a vertical position to act as supporting pillars for the concrete filling in case the riprap filling should settle away from the concrete.

Covers of reinforced concrete were molded in the manhole tops to close the openings (see Fig. 3).

A mixer mounted on a scow was used for mixing the concrete for the filling and for the superstructure. This mixer was set at an elevation which permitted dumping the mixed material directly from the mixer into a chute from which the wet mixture flowed into the work.

Intervals Between Caissons.—The intervals 12 ins. in width between caissons were filled with small stone to within 1 ft. of the top, and then covered with a 3x12-in. board, on which a filling of 1-3-5 concrete was placed. This filling was brought up to the top of the caissons and given a finished surface the same as the caisson filling.

Superstructure.—A superstructure of 1-3-5 concrete of the form and dimensions shown on the drawing was built to an elevation of 4 ft. above datum. The superstructure was built in sections 25 ft. in length, the joint between sections being made coincident caissons. Alternate isolated sections were first molded and then the intermediate sections, a layer of building paper being placed between each section to provide against temperature changes. The concrete in the superstructure was deposited from a mixer on a scow in the same manner as the concrete filling.

Cost of Work.—The plant purchased for the manufacture of the concrete caissons, not counting as plant the launching ways or the cement warehouse, amounted to $5,778.27, distributed as follows:

3-ton traveling derrick and installation of same	$2,283.05
Small derrick and installation of same	59.03
Concrete mixer; Smith No. 2½ and installation of same	860.63
Narrow gage railway and 4 flat cars	344.78
Gasoline engine, pump tank and pipes for water supply	429.33
Buckets and skips	233.75
Cement testing apparatus	387.05
Timber and blocking in yard	207.00
Towing equipment	41.26
Shed for steel	13.57
Telephone and office equipment	49.36
Clearing yard	94.97
Small tools	145.12
Miscellaneous supplies	629.37
Total	$5,778.27

The three sets of launching ways cost $3,684.52, made up of the following items:

Piles	$1,202.40
Timber	715.80
Excavating and dredging	441.11
Labor and miscellaneous supplies	1,322.21
Total	$3,684.52

A temporary warehouse for storing cement, 49 ft. by 24 ft. was erected at a total cost of $521.40.

Three sets of forms were used for the Algoma and Manitowoc caissons. The cost of these was $1,839.57, distributed as follows:

Lumber	$ 532.60
Rods and turnbuckles	26.55
Bolts	109.76
Iron plates	23.10
Mill work	153.79
Labor	993.77
Total	$1,839.57

As there were 1,045 cu. yds. of concrete in the Algoma caissons and those for Manitowoc will amount to 980 cu. yds., a total of 2,025 cu. yds. will have been molded in the forms, making the cost of forming $0.908 per cu. yd.

In the following cost analysis, the charge to the work on account of plant is based on the depreciation of same and the interest on the investment, as the plant is portable and has considerable value for future work. Launching ways and warehouse, as stated before, are not here included in the item plant, as they are not portable and must be treated differently. Credit is taken for the present value to the United States of the launching ways, which is estimated at $2,165.77, making the amount chargeable to the Algoma and Manitowoc caissons $1,518.75. The cement warehouse is assumed to have no present value and is charged entirely to the Algoma and Manitowoc caissons. It is probable that a contractor doing similar work would charge the entire cost of the launching ways to the work, for these would be of no value to him on the completion of the job, unless he could then find a purchaser for them.

The amount chargeable on account of the plant is as follows:

Depreciation, 10% of cost	$577.83
Interest on cost, 6% for 12 months	346.70
Total	$924.53

The amounts chargeable to every cubic yard of concrete in the Algoma caissons will therefore be as follows: On account of cement warehouse, 521.40 ÷ 2,025 = $0.257; on account of launching ways, 1,518.75 ÷ 2,025 = $0.750; on account of plant, 924.53 ÷ 2,025 = $0.457.

The following is the cost of the materials entering into the construction of the 20 caissons for the breakwater, as well as the cost of fuel, oils and miscellaneous supplies:

Portland cement		$1,619.20
Sand and stone		1,356.25
Nails and spikes		81.00
Bolts		224.28
Brackets for supporting core		153.05
Eye bolts		87.63
Oakum		6.90
Lubricating oils		29.32
Tallow		23.60
Gasoline		6.00
Coal		168.96
Reinforcing steel in caissons, 259,327 lbs.	$4,985.22	
Flat bars for spacing	139.64	
Wire	9.82	5.134.68
Timber in caissons and decks, 48,924 ft. B. M.		1,332.90
Total		$10,223.77

The cost of labor, including superintendence, was as follows:

Unloading cement	$ 104.72	
Setting up forms	1,221.75	
Molding	1,160.35	
Removing forms	242.43	
Waterproofing	52.00	
Testing	13.47	
Repairing and cleaning forms	192.29	
Launching	390.89	
Care of caissons afloat	35.70	
Handling crushed stone	198.88	
Care of plant	202.72	
Miscellaneous	55.50	3,870.70
Unloading steel	90.65	
Placing steel	466.32	556.97
Transferring timber	45.60	
Spiking and framing floor timbers	160.56	
Placing decks, guide timbers, etc.	677.70	883.86
Total		$5,311.53

From the above it is computed that the total cost of labor and materials for 1,045 cu. yds. of reinforced concrete in 20 caissons was as follows:

Concrete:	
Materials	$3,756.19
Labor	3.870.70
	$7.626.89
Cost per cubic yard exclusive of warehouse, ways, plant, forms, steel and timber	$7.297
Reinforcing steel:	
Materials	$5.134.68
Labor handling and placing	556.97
	$5,691.65
Cost of steel, plus cost of placing in the work, per pound	$0.0219
Timber:	
Materials	$1,332.90
Labor, handling and framing	883.86
	$2,216.76
Cost of timber and cost of placing in the work, per M. ft. B. M.	$45.31

A unit price of concrete, exclusive of steel and the placing thereof, based on the foregoing, would be as follows:

	Per Cubic Yard
Cement warehouse	$0.257
Launching ways	0.750
Plant	0.457
Forms	0.908
Labor and materials	7.297
Total	$9.669

The cost of all labor and materials in the 20 caissons, exclusive of ways, warehouse, plant, and forms, was as follows:

Concrete	$ 7.626.89
Reinforcing steel	5,691.65
Timber	2,216.76
	$15,535.30=$776.77 per caisson

Including the above allowances for ways, warehouse and forms, the cost for 20 caissons would be as follows:

Launching ways	$ 783.75
Warehouse	268.57
Plant	477.57
Forms	948.86
Concrete	7.626.89
Reinforcing steel	5,691.65
Timber	2,216.76
	$18,014.05=$900.70 per caisson

The cost of towing was as follows:

Cost of towing all caissons, 6 at $20, 14 at $23	$442.00
Cost per cubic yard	0.423

The deck was removed from each caisson as soon as received and the pile tops which supported the upper four feet of concrete were then put in place. The total cost of this work was $329.07, or $16.45 per caisson.

The cost of the special plant acquired, for the caisson work of the breakwater was as follows:

Concrete mixer, complete, and installation of same	$1,450.75
Concrete tools	5.70
Saws and saw frames for cutting off piles under water	37.00
Special tools, clam-shell bucket, paulin, etc.	415.55
Scow repairs	48.38
Miscellaneous	229.50
	$2,186.88
Half value derrick and scow (other half charged to riprap)	1,650.00
	$3.836.88

All of the above plant is portable and will be treated the same as plant used for molding caissons in arriving at a charge for plant against every cubic yard of concrete:

Depreciation, 10% of cost	$383.69	
Interest on cost, 6% for 12 months	230.21	$613.90

The second cement warehouse at Algoma, Wis., 49x24 ft., cost $489.81, and the forms for superstructure cost $221.02, while those for the manholes in the concrete filling cost $24.22.

A total of 1,241 cu. yds. of concrete was made and deposited in the concrete breakwater after sinking the caissons, 820 cu.

yds. of meagre [illegible] filling and 121 cu. yds. of superstructure and intervals between caissons.

The amounts to be charged to every cubic yard of concrete for plant, warehouse and forms are as follows:

Plant	[illegible] / 1241	$0.40[illegible]
Cement warehouse	459.81 / 1241	[illegible]
Superstructure forms	[illegible] / 1241	[illegible]
Manhole forms	[illegible] / [illegible]	[illegible]

The cost of all labor and materials in the 820 cu. yds. of concrete filling was as follows:

Cement, 682 bbls. at $1.13	$ [illegible]
Crushed stone, 881 cubic yards at $1.25	1,[illegible]
Handling cement	[illegible]
Handling crushed stone	2[illegible]
Labor mixing and placing	1,[illegible]
Fuel	1[illegible].17
	$3,220.[illegible]

This places the cost of the meagre concrete at $3.927 per cu. yd. for the preceding items.

Including the cost of plant, forms and warehouse, the cost is as follows:

Plant	$0.407
Warehouse	0.[illegible]
Forms	0.0[illegible]
Labor and materials	3.927
	$4.817

The cost of the labor and materials in the 121 cu. yds. of concrete superstructure was as follows:

Cement, [illegible] bbls. at $1.13	$ 611.80
Crushed stone, 120 cubic yards	[illegible]
Handling cement	24.6[illegible]
Handling crushed stone	1[illegible]
Labor mixing and placing	1,1[illegible]
Fuel	[illegible].77
	$2,512.39

The cost of the concrete in the superstructure thus becomes 2,512.39 ÷ 121 = $[illegible] per cu. yd.

Including proper charges for plant, forms and warehouse, the cost becomes:

Plant	$0.407
Warehouse	0.[illegible]
Forms	0.[illegible]
Labor and materials	[illegible]
	$[illegible]

The piles in the foundation cost as follows:

Piles	$2,[illegible]
Cutting pile caps	[illegible]
Handling piles	[illegible]
Sharpening piles	[illegible]
Driving piles	[illegible]
Sawing off piles	[illegible].47
Leveling piles and preparing foundation	[illegible]
	$[illegible]

As there were 376 piles used in the foundation, the cost per pile in the work, not including charge for plant, was $[illegible] ÷ 376 = $10.[illegible].

Allowing 10 per cent depreciation on a $2,000 pile driver and interest for 17 months at 6 per cent on this driver, $[illegible] must be added to the above, making the total $4,[illegible]. The cost per pile driven then becomes $4,2[illegible] ÷ 376 = $11.[illegible].

The riprap consisted of large and small stone and some stone dredged from old work by the United States Army. The cost was as follows:

Large riprap stone purchased 1,724 tons at $1.16	$1,87[illegible]	
Small riprap stone purchased [illegible] tons at $[illegible]	[illegible]	
Labor placing riprap on caissons and caisson backing	1,738.[illegible]	
Total cost of stone purchased		$[illegible]
Riprap dredged for caissons 1,221 tons at 25 cents	$305.[illegible]	
Time of dredge in casting riprap 16½ hours, at $[illegible]	[illegible]	[illegible]
Total cost of riprap stone in place, exclusive of plant charge		$[illegible]
Plant used on riprap valued at $[illegible]		
Depreciation on same, 10%	$[illegible]	
Interest for 17 months at 6%	[illegible]	[illegible]
Total cost of riprap stone in place, including plant charge		$[illegible]

From the above the average cost in place of riprap stone purchased was $1.11 per ton, exclusive of plant. This price is somewhat high, which is due to the fact that most of the stone had to be handled twice on account of the size and draft of the boats on which it was delivered.

The cost of the completed 511.7 ft. of concrete breakwater from the above becomes as follows:

Caissons complete	$18,[illegible]
Towing caissons	442.[illegible]
Removing decks and preparing caissons for sinking	[illegible]
Setting ranges and preliminary work	71.81
Piles and pile caps	2,[illegible]
Handling, driving, cutting off of piles	1,[illegible]
Concrete filling, labor, materials and superintendence	[illegible]974.[illegible]
Concrete superstructure, labor, materials and superintendence	[illegible]
Riprap stone and handling same	[illegible]
Towing with gasoline launch	[illegible]
Miscellaneous supplies	181.[illegible]
	$38,718.78

As there were 511.7 ft. of concrete breakwater, the cost per linear foot of completed structure is 38,718.78 ÷ 511.7 = $75.67.

Estimated cost per linear foot	$103.74
Actual cost per linear foot	75.67
Difference between estimated cost and actual cost	$28.07

Cost of Constructing a Reinforced Concrete Siphon for the Sun River Irrigation Project.*

The Simms Creek siphon is a reinforced concrete structure 1,565 ft. long, with an inside diameter of 5 ft. 3½ ins., and operates under a maximum head of 40 ft. The work was done by force account except that the trench excavation was constructed under contract at 25 cts. per cu. yd. It was begun in October, 1907, and completed in March, 1908. Where the siphon is in trench, it is underlaid with gravel and tile pipe, the under-drainage being intercepted by concrete cut-off walls 25 ft. apart on the east slope and 50 ft. apart on the west slope. The cement cost $2.60 per barrel, and the reinforcing steel $0.0212 per pound, delivered. The haul for cement and reinforcing steel was 25 miles, and that for sand and gravel 2 miles. Collapsible steel interior forms were used, and an average of 18 lin. ft. of pipe was laid per day. Concrete was mixed in the proportions 1 : 2 : 4. Labor and weather conditions were favorable, and the rate of wages for labor per 8-hour day varied from $2.25 to $2.75. Two foremen were employed at $125 per month, one carpenter foreman at $5.50 per day, and carpenters at $4.50 per day.

In addition to the total cost distributed in the table there were certain expenditures that could not readily be distributed to the items of work, the relative proportions of which are shown in the following: Distributed cost, $[illegible]; trench excavation, $1,167.76; construction of buildings, $1,826.50; hauling and placing rock for riprap, $88.11; surveys and design, $1,058.98; depreciation of buildings, $258; making a total of $36,750.8[illegible], or a total unit cost of $23.49 per foot of siphon.

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*Reprinted from the "Reclamation Record" for May, 1909.

The Port Commissioners of Calcutta, India, are considering building a new bridge across the Hooghly at Howrah. This would naturally be a part of the great work which has been effected and which is in contemplation in the building of jetties and docks at this port. The proposed bridge would cost $1,070,000.

The Chinese Government is asking bids for the construction of a group of buildings to be used as a bureau of engineering and printing in Pekin. The plans for the buildings were prepared by Milburn, Heister & Co., Architects, Washington, D. C. Bids from American and European contractors must be filed through the Chinese Legation, at Washington, D. C.

During the month of April [illegible] cu. yds. of masonry were laid in the Roosevelt Dam of the Arizona, Salt River Project of the U. S. Reclamation Service, bringing one-half of the length of the dam to an average elevation of 187 ft. and the other half to an elevation of 112 ft. above the floor of the sluicing tunnel. At the end of April the dam was 71 per cent completed.

SUN RIVER PROJECT, SIMMS CREEK SIPHON; COST AND UNIT COSTS.

	Reinforced concrete				Underdrain	
	Pipe 1,565 lin. ft.		Flume, intake, etc. 212 cu. yds.		1,5[illegible] lin. ft.	
Distribution of cost	Total	Unit	Total	Unit	Total	Unit
Engineering	$1,2[illegible]	$.[illegible]	$ [illegible]	$ [illegible]		
Superintendence	[illegible]	[illegible]	[illegible]	[illegible]		
Preparatory expense	[illegible]	[illegible]	[illegible]	[illegible]		
Administration	[illegible]	[illegible]	[illegible]	[illegible]		
Camp maintenance	[illegible]	[illegible]	[illegible]	[illegible]		
Labor:						
Hauling sand and gravel	[illegible]	[illegible]	[illegible]	[illegible]	$ [illegible]	$[illegible]
Hauling cement and steel	[illegible]	[illegible]	[illegible]	[illegible]		
Hauling wood, water and other supplies	[illegible]	[illegible]	[illegible]	[illegible]		
Pumping			[illegible]	[illegible]		
Making forms	1,[illegible]	[illegible]	[illegible]	[illegible]		
Bending and placing steel	[illegible]	[illegible]	[illegible]	[illegible]		
Mixing and placing concrete	[illegible]	[illegible]	[illegible]	[illegible]		
Excavation	[illegible]	[illegible]	[illegible]	[illegible]		
Underdraining					[illegible]	[illegible]
Moving forms	[illegible]	[illegible]	[illegible]	[illegible]		
Handling forms	[illegible]	[illegible]				
Materials:						
Lumber	[illegible]	[illegible]	[illegible]	[illegible]		
Steel	[illegible]	[illegible]	[illegible]	[illegible]		
Cement	[illegible]	[illegible]	[illegible]	[illegible]		
Vitrified pipe					[illegible]	[illegible]
Supplies:						
Steel forms and supplies	[illegible]	[illegible]				
Building and removing plant	[illegible]	[illegible]	[illegible]	[illegible]		
Depreciation	[illegible]	[illegible]	[illegible]	[illegible]		
Miscellaneous	[illegible]	[illegible]	[illegible]	[illegible]		
General expense	[illegible]	[illegible]	[illegible]	[illegible]		
Totals	$2[illegible]	$[illegible]	$[illegible]	$[illegible]	$[illegible]	$[illegible]

Earth and Rock Section

Note: This Section is devoted to methods and costs of excavating earth and rock and building embankments. It will cover the grading of roads and railroads, diking and canal work, dredging, building reservoirs and earth dams, sewer and water pipe trenching, quarrying, etc.

Cost of Excavating Canal, Klamath Irrigation Project.*

About 12.3 miles of South Branch Canal on Klamath Project were constructed under two contracts during the season of 1908 and part of 1909. The upper end of the canal is about 8 miles from Klamath Falls, and the whole of the work was divided into eight schedules averaging about 1½ miles in length. Schedules 1, 2 and 3 were constructed under contract, the greater part of the work being done from May to December, 1908. The excavation of about 8,000 cu. yds. on schedule 1 was delayed until the spring of 1909 and was finished in March. On schedules 1 and 3 the bottom width is from 15 to 18 ft. and the slopes are 1½ to 1. On schedule 2 the canal is built entirely in embankment with a bottom width of 3.8 ft. and side slopes of 1½ to 1. On this schedule the material for the outer triangles of the canal banks, amounting to about 40 per cent of the total, was deposited in 12-in. layers in the ordinary manner of building embankments, but the other 60 per cent of the material, was deposited in 6-in. layers, sprinkled, and rolled. Schedules 4, 5, 6, 7 and 8 were constructed under formal contract and informal specifications, the greater part of the work being done from August to December, 1908. A small amount of work on schedules 4 and 8 was done in the winter of 1908-9, and finished in March, 1909. For all of schedules 4, 5, 6, 7 and 8 the bottom width of canal is 11.5 ft. and the side slopes 1½ to 1.

On all scredules most of the material excavated was earth that could be plowed by six-horse teams, and in general no bad conditions were encountered. A small amount of indurated material that required blasting before scrapers could be used was encountered, but no separate estimate of the cost of excavating this material was kept. The per cent of this material in terms of the whole amount of excavation on the several schedules is, however, tabulated with the unit costs.

On the first contract, covering schedules 1, 2 and 3, an estimate of interest on investment is made at 6 per cent per annum on the estimated value of animals and equipment. For the second contract, covering the other schedules, no estimate of interest on investment has been made. For both contracts an estimate of depreciation of equipment has been made at 2 per cent per month on the total value thereof. The weather and labor conditions were generally good under both contracts. The wages for common labor were $2 per day, and the cost of animals, including depreciation, was estimated at $1 per day each.

There are tabulated below the unit costs of the work, including cost to the contractors and the engineering expenses of the United States, together with other useful information relating to the work.

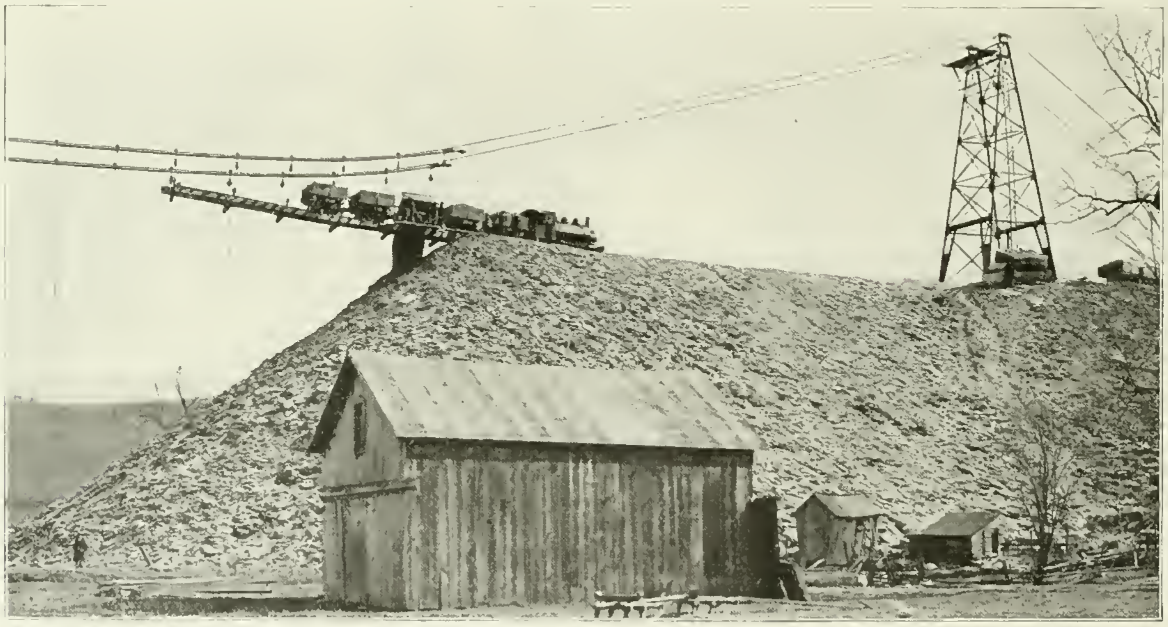

Fig. 1.—Aerial Cableway Bridge Making 80-ft. Fill on Delaware, Lackawanna & Western Ry.

COST OF EXCAVATING SOUTH BRANCH CANAL, KLAMATH IRRIGATION PROJECT.

Schedule No.	1	2	3	4	5	6	7	8
Length, miles	1.27	1.36	3.0	1.3	1.33	1.33	1.33	1.56
Quantity, cubic yards	54,734	163,987	71,895	21,116	23,209	22,613	23,035	27,933
Aggregate cost	$3,077	$30,230	$10,212	$4,210	$3,710	$2,660	$3,670	$4,750
Per cent of indurated material	23	0	5	5	1	0	1⅔	0
Winter work	2 mos.	none	none	2 mos	none	none	none	1 mo.
Cubic yards (per man day)	23	33	36	22	32	44	31	27
Cubic yards (per horse day)	16	17	23	15	18	28	20	17
Interest	$0.005	$0.003	$0.003	.....	.....	.....	.....	.....
Preparatory expense	.009	.006	.008	$0.002	$0.002	$0.002	$0.002	$0.002
Depreciation	.007	.006	.004	.003	.003	.003	.003	.003
Executive	.016	.008	.007	.008	.008	.008	.008	.008
Superintendence	.012	.006	.003	.014	.007	.007	.009	.013
Labor:								
Plowing, men	.014	.006	.008	.013	.009	.006	.008	.009
Plowing, horses	.013	.008	.008	.014	.009	.004	.010	.008
Scraping, men	.045	.033	.027	.033	.028	.019	.023	.027
Scraping, horses	.048	.050	.033	.052	.048	.032	.041	.050
Loading and dumping	.018	.010	.008	.021	.012	.010	.014	.014
Sprinkling and rolling	...	.003	...	...	...	...	...	...
Finishing and sloping	.007	.005	.008	.014	.011	.006	.013	.016
Miscellaneous	.009	.007	.003	.008	.007	.006	.012	.004
Supplies	.024	.021	.009	.006	.005	.003	.005	.005
Engineering and inspection	.013	013	.013	.011	.011	.011	.011	.011
	.240	.185	.142	.199	.160	.117	.159	.170

Designs for a new bridge across the Mississippi River at St. Louis are well on toward completion in the office of Boller & Hodge, of New York city. The bridge will be about two miles long, is estimated to cost $3,500,000 and is planned by the city of St. Louis. According to reports there will be three 670-ft. spans with simple pin-connected through trusses 110 ft. deep and 35 ft. apart on centers, proportioned to carry a 30-ft. roadway with two trolley tracks, between trusses on the upper deck, which will have a reinforced concrete floor, wood block pavement and two 6-ft. granolithic antilever sidewalks. The lower deck will have two railroad tracks proportioned for E60 locomotives. The superstructure of the main spans will weigh about 5,000 tons each and will be supported on stone-faced, concrete river piers and of a maximum height of about 100 ft. above low water level, with pneumatic caisson foundations carried down to a maximum depth of about 104 ft. below low water.

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*Condensed from the "Reclamation Record" for May, 1909.

An Aerial Cable Bridge for Making Drop Fills.

In our issue of Oct. 2, 1907, we described the construction and gave the cost of an aerial cable bridge used in making a [illegible] ft. fill on the Lake Erie & Pittsburg Ry. The same type of structure, in an improved form, is now being employed to construct an embankment some 1,100 ft. long and [illegible] ft. high on the Delaware, Lackawanna & Western Ry. near [illegible], N. J. The accompanying views show the plant and the work in operation. Briefly described the cableway structure consists of a stationary tower and a movable tower which carry two parallel cables. Suspended from the cables is a platform which carries a dump car track. The general arrangement is clearly indicated by Fig. 1, and a description in more detail follows. It should be first stated, however, that this aerial cable bridge is patented and controlled by the New York Cableway & Engineering Co., of New York City.

The fixed tower shown in the distance of the general view Fig. 2 is practically the standard cableway tower guyed and held in place by its own weight and the pressure of the cables. The portable tower shown in the right foreground of both views is made of steel and so put together that it can be easily taken down. This tower is 25 ft. wide across track, 20 ft. wide in the direction parallel with the track, this width decreasing to 12 ft. at the top, which is some 70 ft. above ground. The arrangement of the tower framework is well shown by the views. The tower moves on a 20 ft. gage track laid on the fill. The movement is by skidding, horizontal steel plates being attached to the feet of the tower legs. At the top of the tower are special saddles for the cables.

The cables used in the work illustrated are spaced 12 ft. apart and extend from an anchorage back of the stationary tower to an adjustment back of the portable tower. They are 2¼ in. wire rope cables. They carry suspenders which support the track platform; these suspenders are spaced 12 ft. apart on each cable and are held to proper spacing by connecting bars of 1½x½ in. steel. Each suspender consists of a four-wheel trolley carrying strap hangers on each side which support a [illegible] block. A [illegible] cable is run through this block and supports in its bight another [illegible] block, which [illegible] a staple bolt. The staple bolts of [illegible] hangers pass through and support the platform girders. The block and tackle construction of the suspenders, as will be seen, permits their length to be adjusted vertically, so that the track platform can always be kept level. The platform girders, as will be understood, are across-track, one end being supported by the suspender from the right hand cable and the opposite end being supported by the suspender from the left hand cable. These girders carry two lines of stringers on which are laid the two rails of the dump car track.

In operation the fill is started at the portable tower, the cars being hauled out from the solid embankment onto the suspended platform track and dumped, a car at a time, just at the top edge of the fill. By this arrangement it will be seen that practically only empty cars are carried by the suspended platform; the view Fig. 1 illustrates this quite clearly. At the start of work the platform is suspended quite close to the tower, but as the embankment is filled out the platform is moved away from the tower as shown in Fig. 1. The method of moving the platform constitutes one of the interesting features of the plant.

As mentioned above the row of suspenders on each cable are spaced and connected by a sort of chain of connecting bars. The platform and its suspenders thus constitute an assemblage which can be moved as a unit riding on the main cables. To keep this assemblage at a fixed distance from the tower (it would have a tendency, of course, to slide down hill on the cables as they sag down from the tower top) a cable is attached to the near ends of the chains of connecting bars, then carried up and over a sheave at the tower top, and thence down to the base of the tower and fastened. By letting out this cable the bridge or platform is free to move out away from the tower on the cables. To permit this movement a cable attached to the far ends of the chains of connecting bars runs to a sheave at the far tower and thence back again to the portable tower, where its free end is attached to the locomotive for moving the dump cars, and pulled on, hauling the platform forward to its new position.

As the work advances the top of the fill and the sag of the cables approach each other until there is no room between the [illegible] track and cable for the cars. This condition is postponed as long as possible by shortening the [illegible]; in Fig. 1 the [illegible] had been reduced to [illegible] from the original [illegible] height, but finally it is necessary to take up the sag in the cables by moving up the portable tower and "taking-up" the cables. This "taking-up" is accomplished by the adjustment previously mentioned. The adjustment consists of two sheaves, mounted respectively to the upper and lower ends of the [illegible] cable at the rear of the tower with a line of [illegible] between sheaves. By working [illegible] at Fig. 2 the [illegible] cable may be taken up and [illegible].

On the work illustrated the capacity of the bridge is handling some 1,200 cu. yd. of material per day, the [illegible] being not the [illegible] of the bridge, but the amount which can be excavated daily from the cut further back, material from which is [illegible]. It will be noted that the plant required no power other than that of the locomotive used for hauling material trains. It is readily dismantled and transported. Its salvage value is large. The contractors operating the plant illustrated are the Hyde-McFarlin-Burke Co., of New York City.

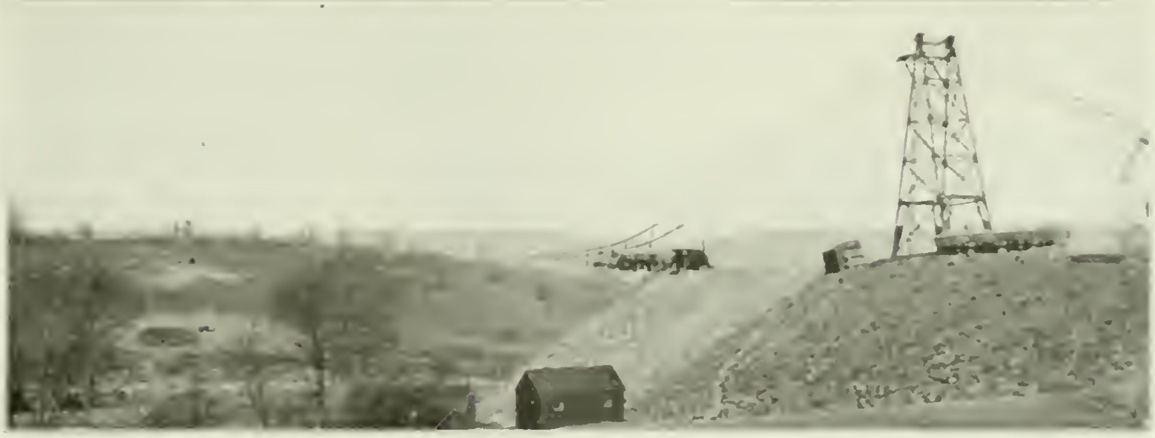


Fig. 2—General View of Aerial Cableway Bridge and of Valley Crossed by Rock Fill.

The town of [illegible], in Whitman County, Washington, according to press dispatches, is using wheat straw on its streets as a means of binding the mud in the spring and keep down the dust later on. Two miles of streets were covered this spring, a foot of fresh straw being laid from curb to curb, and packed into the wet ground following a slight rainfall. The experiment is said to have been a success.

The cost of filtering water by the slow sand method is given as follows in the 1907 report of the Lawrence, Mass., Water Board. During that year [illegible] gals. were filtered at a total cost of $11,[illegible], or about $[illegible] per 1,000,000 gals. The itemized cost per 1,000,000 gals. was: Removal of ice and snow, $[illegible]; scraping, $1.[illegible]; sanding, $[illegible]; washing and removing sand, $[illegible]; labor, maintenance and extras, $[illegible]; care of grounds, $[illegible].

It is stated that [illegible] Chinese Viceroy [illegible] a project of [illegible] Shanghai and [illegible] the [illegible] Company's [illegible] printing offices [illegible].

Sir Robert William Perks, of London, has made a proposition to the Canadian Government [illegible] the construction of the Georgian Bay ship canal provided the government would guarantee the bonds of the company [illegible] 3 per cent.

Roads and Streets Section

Note: This Section is devoted to methods and costs of road and street construction. It will cover road building in all its details, the construction of pavements, sidewalks and gutters, the testing and use of paving materials and the machinery and tools used in road building and paving.

The Theory of Economic Road and Street Design and Location.

VI.

The Economic Effect of Increased Speed of Light Vehicles Over Hard Roads.—Thus far we have considered only the economies of hauling heavy loads over paved roads. In many localities there is a very important traffic consisting of vehicles carrying light loads, such as dairy products, "garden truck," etc. When earth roads are hard and dry, there is little gain in the speed with which such loads can be hauled, as compared with paved roads; but, after rains or in dry weather, most earth roads are covered with mud or dust to such an extent as to decrease the horse mileage very materially.

A horse that is traveling at a 5-mile trot can exert less than half the tractive pull that can be exerted at a 2½-mile walk. If a horse exerts a tractive pull of 50 lbs. at a trot, it is capable of hauling a vehicle and load having a combined weight of 1,000 lbs. over an earth road offering a tractive resistance of 100 lbs. to the ton. But where there is mud 2½ ins. deep, the resistance becomes 2½ times as great, or 250 lbs. per ton; and where the wheels sink into clay mud 6 ins. deep, the resistance is nearly 500 lbs. per ton. Therefore even with only half a ton of vehicle and load to haul, a horse can not go faster than a walk in mud that is only 2½ ins. deep. There are many sections of the country where such mud exists on the roads for at least 60 working days yearly (excluding the winter months entirely). Every bit of light hauling done during those sixty days is done at double the cost that would exist were paved roads available. How much light hauling of this character exists in any given section should be estimated by the engineer and due allowance made for it in arriving at the total expenditure justifiable in paving a road.

The Economics of Maximum Grades.—A maximum grade is the steepest ascent on a road. It is commonly said that the maximum grade determines the size of load that can be hauled. While this is true on a railway, it is subject to qualification on a road where horses are the motive power. A locomotive has a certain definite tractive power limited by the adhesion of the wheels to the rails, but a horse can double, triple, or quadruple his normal tractive power for a short time. Hence if a 2½-ton load (including the wagon or cart) offers a tractive resistance of 125 lbs. on the level, and if this is as much as a horse should be called upon to *average*, it does not follow that the horse is incapable of pulling that load up a grade even as steep as 4 per cent. The 2½ tons will require a tractive effort of 200 lbs. to overcome the 4 per cent grade resistance, plus the 125 lbs. tractive resistance, or a total of 325 lbs. This pull is within the capacity of the horse, if exerted for a short time, with intervals of rest. Hence it is that maximum grades on roads are of less economic importance than on railways. Nevertheless they merit study.

The writer has had a team of horses pull 5 tons of stone (6 tons including wagon) up a 5.3 per cent grade on a macadam road, thus exerting a pull of more than 800 lbs., even assuming only 30 lbs. per ton of tractive resistance on level macadam. Each horse weighed about 1,600 lbs., and therefore exerted a pull equal to ¼ of his weight. The grade was 1,200 ft. long, and several short stops were made.

To determine the maximum grade that can be used without decreasing the load that can be hauled on the level, apply the following rule:

Ascertain the average load (including the wagon) that a horse can haul on the level, assuming an average tractive pulling power equal to 10 per cent of its weight, and a tractive resistance of 20 to 100 lbs. per ton depending on the nature of the road surface. Then ascertain the excess tractive power of the horse (available for short, hard pulls) by taking 15 per cent of its weight, and divide this by 20 times the load (including wagon); the quotient is the maximum grade that can be overcome without reducing the load.

This rule is based on the assumption that a horse can exert a maximum tractive pull of 25 per cent of his weight while going up a steep grade.

As a matter of fact, this is a conservative estimate, for, where the foothold is good, a team of light mules has been known to exert an average pull of 1,000 lbs. when going up a steep grade on an earth road. (See tests made by the U. S. Department of Agriculture). If the mules weighed as much as 1,200 lbs. each, this is equivalent to a pull of 40 per cent of their weight, in addition to lifting their own weight up the hill.

In his "Roads and Pavements," p. 51, Baker makes the mistake of assuming that a horse can exert a maximum tractive effort of only 25 per cent and that from this must be subtracted the power required to lift its own weight.

If it is desired to consider the work done in raising the weight of the horse up the grade, then we should ascribe to the horse a maximum working capacity equivalent to a tractive pull of at least 30 per cent of its weight when traveling at a walk. In which case the rule for ascertaining the maximum grade would be:

Ascertain the load (including wagon) that a horse can pull on the level, assuming an average tractive pulling power equal to 10 per cent of its weight. To this load add the weight of the horse itself and multiply by 20; divide this product into 20 per cent of the weight of the horse, and the quotient will be the desirable maximum grade.

Application of these two rules will show that they do not give materially different results, and since neither the tractive resistance of the road nor the maximum tractive power of the average horse can be estimated with great accuracy, it seems best to apply the first rule above given. For practical purposes it is well to assume some definite average weight of horse, such as 1,200 lbs., and reduce that rule to a simpler form, thus:

Ascertain the average load in tons (including wagon) that a horse can pull on the level, by dividing 120 by the tractive resistance in pounds per ton (say 40 lbs. for macadam and 80 to 100 lbs. for hard earth road). Multiply this load by 20 (since each 1 per cent grade offers 20 lbs. per ton resistance) and divide into 180 (the excess tractive power of the horse available for short periods of time); the quotient is the desirable maximum grade.

Applying this rule to macadam having 40 lbs. tractive resistance per ton, we have $120 \div 40 = 3$ tons (including wagon) as the average load for a horse on the level. Then $180 \div (3 \times 20) = 3$ per cent, which is the maximum grade that this 3-ton load can be hauled up.

Applying this rule to an earth road having 100 lbs. tractive resistance per ton, we have $120 \div 100 = 1.2$ tons (including wagon), as the load on the level. Then $180 \div (1.20 \times 20) = 7.5$ per cent, which is the maximum grade that this 1.2 tons can be hauled up.

To estimate the net load, assume the weight of a large one-horse cart at ½ ton, and of a two-horse wagon at 1 ton.

Some of the earlier writers on roads have advocated a maximum grade not greater than the slope of repose, so that a horse can trot down hill without the necessity of using brakes to hold the vehicle back. This would give a maximum grade of 2 per cent on good macadam, and 4 or 5 per cent on hard earth roads. There is no economic justification for any such reasoning. Nor, in fact, should the above rule be applied without further consideration of the economics of the problem.

It frequently costs many thousands of dollars to secure maximum grades as low as 3 per cent on even 5 per cent. The question that confronts the engineer is whether a given expenditure is justifiable in order to secure the maximum grade which the above rule indicates as being desirable in order not to reduce the average load hauled. Clearly the answer to this question is found in the following rule:

Select a maximum grade such that the total excess cost of securing it, as compared with the "desirable maximum grade" (ascertained by the above rule), shall not exceed the capitalized value of the increased annual cost of hauling the tonnage over that grade.

In applying this rule, the procedure is as follows: Determine the "desirable maximum grade," which on macadam having a tractive resistance of 40 lbs. per ton is 3 per cent, as above shown. If there are steeper natural grades on the road, select some grade, say, 5 per cent as a tentative maximum, and estimate the difference between the cost of grading the entire road to a 5 per cent maximum and to a 3 per cent "desirable maximum." Let us assume that this difference is $3,000.

Next ascertain the number of tons (that a 1,200-lb. horse can haul up the proposed 5 per cent grade, by applying the following rule:

The load in tons (including wagon) that a 1,200-lb. horse can pull up any given grade on a paved road having a tractive resistance of 40 lbs. per ton is found by adding 2 to the per cent of grade and dividing this sum into 15.

Thus on a 5 per cent grade we have $2 + 5 = 7$, which divided into 15 gives 2 1/7 tons as the maximum load.

[The above rule is deduced thus: Let x be the number of tons that a 1,200-lb. horse can haul up a grade of r per cent. Assuming the horse capable of exerting a maximum tractive pull of 25 per cent of its own weight, we have 300 lbs. tractive pull going up the grade. Since grade resistance is practically 20 lbs. per ton for each 1 per cent of grade we have 20 r x as the grade resistance. On macadam having 40 lbs. tractive resistance per ton, the total macadam resistance is 40r, on the level. Therefore we have 20 r x + 40 r = 300

$$x = \frac{15}{r + 2}$$

which is expressed in the above rule.]

A gross load of 3 tons per horse, or 6 tons per team, is equivalent to a net load of about 5 tons per team on a 3 per cent grade.

A gross load of 2.1 tons per horse, or nearly 4.3 tons per team, is equivalent to 3.3 tons net load on a 5 per cent grade.

If teams average 10 miles a day hauling a load (returning 10 miles empty), we have 10 × 5 = 50 ton-miles hauled per team where the maximum grade is 3 per cent, which is equivalent to 6 cts. per ton mile, where a team costs $3 a day.

Where the 5 per cent maximum grade exists we have 10 × 3.3 = 33 ton-miles per team day, at 9 cts. per ton mile. Thus there is a loss of 3 cts. per ton mile.

If there are 5,000 ton miles of traffic that will pass over the maximum 5 per cent grade, the increased cost of the hauling is 5,000 × 3 cts. = $150 annually.

Capitalizing this at 4 per cent, we have $150 ÷ 4 per cent = $3,750, which is the expense justifiable to secure the desirable maximum grade of 3 per cent as compared with the 5 per cent maximum grade. If the difference in first cost is only $3,000, as above assumed, then the $3,000 extra expense of securing the 3 per cent grade is abundantly justified, for it is less than the capitalized value of the annual saving in hauling, which is $3,750.

However, should the total cost of securing a 5 per cent maximum grade be, say, $6,000 in excess of the cost of securing the 3 per cent "desirable maximum," other conditions being as above, then the engineer should assume an even greater maximum grade than 5 per cent, say 6 per cent, and repeat the calculations. This process of assumption of maximum grades must continue until a maximum grade is selected whose excess cost over the 3 per cent "desirable maximum" does not exceed the capitalized value of the annual saving in hauling over the 3 per cent maximum.

Of course, in applying this method of solving the problem of maximum grades, there is to be considered not merely the annual ton mileage already tributary to the road, but the ton mileage that may be reasonably counted upon to develop within a few years after its improvement.

In locating mountain roads for long freight hauls, the engineer should consider the practice of hitching two or more teams to one wagon, leaving the other loaded wagons at the foot of the grade, to be picked up one at a time. Very steep maximum grades are frequently economic when the annual traffic is light and when the character of the hauling is such that several teams can be temporarily hitched to one wagon.

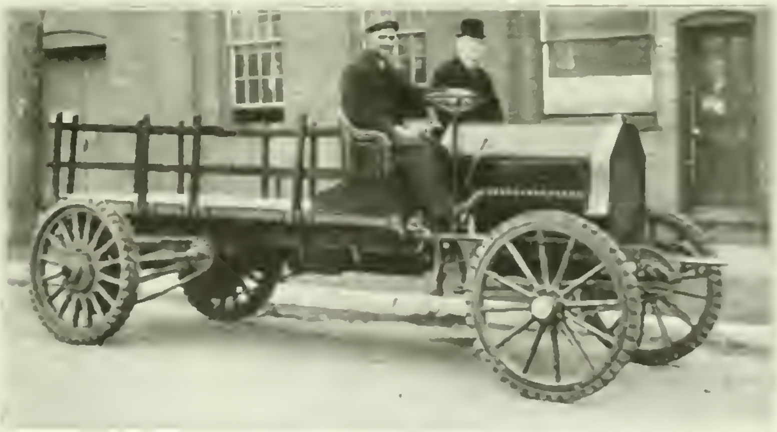
Bear in mind that an economic maximum grade located at end of road farthest from the market may be considerably steeper than the maximum grade near the end of the road close to the market, for the tonnage that passes over any given part of a road usually increases as the market is approached. Hence uniform grades should not be adopted arbitrarily and applied to every part of a long road without consideration of the number of ton-miles that are tributary to each section of the road. By "tributary" we mean that all the tonnage that passes over a given hill should be multiplied by the average distance hauled to market to ascertain the ton-mileage tributary to that hill or grade. If a road is 10 miles long, and if there is a very steep hill 9 miles from the market and another steep hill 1 mile from the market, it may pay richly to reduce the grade on the hill 1 mile from market to, say, 3 per cent, due to the saving effected in hauling a large ton mileage over it, whereas, it may not pay to reduce the grade to less than, say, 7 per cent on the hill 9 miles from market, due to the small ton-mileage that will pass over it.

Although each important hill deserves individual consideration, as just indicated, bear in mind also that a succession of hills having practically the same ton-mileage tributary to each, need not be considered separately, but the *total* cost of securing the "desirable maximum" grade on all these hills should be estimated, and compared with the *total cost* of securing other grades on these hills.

(To be continued.)

A Motor Wagon for Farm Haulage.

In recent articles on improved road economics,* which have been published in these columns, we have spoken of the influence that the motor wagon for hauling farm crops is bound in the future to exert on the economics of improved highways. The time is not many years distant we believe when motor wagons will be commonly used in farm haulage. Among other indications of this ultimate condition of affairs is the fact that automobile manufacturers and makers of agricultural machinery and wagon manufacturers are in many instances studying the possible ways of developing motor wagons for farm use. One of these studies is illustrated in the accompanying engraving, which shows the so-called Farm and City Tractor worked out by the Avery Company of Peoria, Ill., who will be in position to make deliveries on June 1, 1909.



A Motor Wagon for Farm Haulage.

This vehicle has a four-cylinder gasoline motor mounted in front. The chassis will take either a truck or a tight box, a rack or any form of bed for hauling loads on the Tractor. It will pull two or four 14-in. plows, pull a drag or scraper for smoothing public roads, and haul loads on ordinary farm wagons and other vehicles behind it.

The motor shaft extending in front is to be provided with suitable pulley and can be used to [illegible] a small individual farmer's thresher with 22-in. cylinder and 36-in. rear, including all the attachments, pump water, saw wood, bale hay, and do various other tasks required to be done by machinery on the average size farm.

The Tractor does not have pneumatic tires. It has a steel rim perforated and studded with 2-in. hard wood plugs, which enables it to run smoothly and silently on paved streets. These plugs will wear for a great many years and can be renewed at very slight expense. Thus it is called a city tractor as well as a farm tractor because it can run into the city without damage to the paved streets and can be used for all kinds of hauling and trucking for city use. Its hauling capacity is three tons on its own wheels in addition to the weight of the tractor which is 4,000 lbs. The tractor will travel on the public highways 10 to 12 miles per hour and climb the steepest grades with its load. The selling price is $2,500 f. o. b. Peoria.

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* The Theory of Economic Road and Street Design and Location, [illegible] April 14, 21, and 28, and May 5, 12 and 19, 1909.

Per Cent of Compression of Asphalt Wearing Surface.

In 1905 an experiment was conducted under the direction of John C. Sheridan, Chief Engineer of the Bureau of Highways, Borough of Brooklyn, New York City, to determine the per cent of compression of asphalt wearing surface from the loose measurement delivered on the street to that in place. The experiment was on a piece of work 267 sq. yds. in area. The binder was to be 1 in. and the surface mixture 2 ins. thick when laid.

When the concrete foundation was completed ordinates were taken every few feet from a line stretched from curb to curb. These sections were taken about 2½ ft. apart. After the binder was laid, measurements were made from the line over the same points and after the wearing surface was laid, similar measurements were taken at the identical points, the material having previously been measured in the trucks. It was found that there was a shrinkage of 21½ per cent from the loose measure in the truck to the measurement compacted in place and that there was a shrinkage of 33 per cent from the plant measurement to the measurement compacted in place. This was on the wearing surface; the shrinkage in binder was not determined.

The average width of the country highway of the first class in [illegible] is approximately 30 ft. and this width has been found to be ample for all purposes.

Road Treatment Work of the Massachusetts Metropolitan Park Commission in 1908.

During 1908 the Metropolitan Park Commission continued the work of road treatments along the same general line of the preceding year, and to a greater extent. In addition the commission conducted some additional experiments with new mixtures of oil and tar. Tar and a tar and asphalt mixture have also been used in resurfacing work by incorporating the bituminous materials with the stone used.

Practically all of the roadways of the parkways and reservations, which are subjected to automobile traffic, were treated with some material for their preservation. Generally the results have been satisfactory, and all sprinkling with water to lay the dust on these roads has been abolished, as it has been unnecessary.

The accompanying table taken from the last annual report of the commission gives some data on the cost of this work. The figures in the column under cost of bituminous binder includes the material and the labor of applying it. The other figures on the same line for cost of labor refer to the cost of applying sand, gravel or stone screenings over the binder.

In the Blue Hills Parkway the surfaces of the pleasure drive from Neponset river to Blue Hill Terrace, a distance of about ¾ of a mile, and of the traffic road from Neponset River to Canton Ave., a distance of about 1½ miles, were treated with an asphalt oil known as "asphaltoilene." The work was done by the Good Roads Improvement Co. of Cincinnati, O., from June 20, 1908, to July 18, 1908. The cost of this work was at the rate of 6 3-5 cts. per square yard of roadway.

In the Middlesex Fells Parkway both roadways of the parkway from Broadway, Somerville, to the junction with Revere Beach Parkway, and the westerly roadway from the junction with Revere Beach Parkway to Emerald St., a total length of about three miles of roadway, varying in width from 26 ft. to 40 ft., were resurfaced with broken stone. Tar and mixtures of tar and asphalt were used with the resurfacing stone to bond it. The total cost of this work was $17,775.05, or at an average of 33.4 cts. per square yard. The easterly roadway from the junction with Revere Beach Parkway to Salem St. and from Fulton St. to Forest St., and both roadways of Fellsway East from Highland Ave. to Middlesex Fells Reservation, a total length of about 2 miles of 36-ft. roadway and ½ mile of 26-ft. roadway, were surface-treated, partly with a mixture of coal tar and water gas tar, and partly with a mixture of oil and water gas tar. These treatments were effective in preventing dust and mud, and in protecting the surface of these roadways during the past season. The work was done during the month of July, and the total cost has been $2,211.45. This treatment was used where the roadways were in fairly good condition, and at the time of the application did not actually need resurfacing.

In the Mystic Valley Parkway the roadways from High St., Medford, to Main St., Winchester, a distance of about 2½ miles, were surface-treated with a mixture of oil and water gas tar. The proportions used were 4 bbls. of oil to 6 bbls. of water gas tar. The roadway is constructed with a gravel surface, and is 36 ft. in width. The work was done in May and June, at a total cost of $1,758.34, or 3¼ cts. per square yard. The roadways of the balance of the parkway from Main St. to Middlesex Fells Reservation, a distance of about ½ mile, and which are constructed with a macadam surface, were treated with a mixture of coal tar and water gas tar. This work was done in June, about 9,500 sq. yds. were treated, and the total cost was $462.04, or 4 8-10 cts. per sq. yd.

In the Middlesex Fells Reservation Pond St. and Woodland Road, a total length of about 1½ miles of roadway were reconstructed with a broken-stone base and gravel surface. A heavy asphalt oil was combined with the gravel surfacing material. The work was done by the reservation forces, and at a total cost of $9,211. Hemlock Pool Road, a total length of about 4-5 mile of a mile, was reconstructed with a gravel surface. This work was also done by the reservation forces, at a total cost of $948.00. The surfaces of Main St. and Forest St., from South St., Stoneham, to the junction with Fellsway West, Medford, a total distance of about 2½ miles, was treated with mixtures of coal tar and water gas tar, and oil and water gas tar. One application was made, and some slight patching has been done during the latter part of the season. The results were quite satisfactory in preventing dust and protecting the roadway surfaces for most of the year.

In the Revere Beach Reservation the roadway surfaces which were treated in 1907 partly with "tarvia" and partly with "asphaltoilene" were maintained in satisfactory condition during 1908 by patching and a small amount of re-treatment. The northerly portion of the drive nearest the Northern Circle, about 2-3 of a mile in length, which was not treated in 1907 was given an application of "liquid asphalt," making the treated surface complete the whole length of the reservation drive.

During April the progress on the Gunnison Tunnel of the Colorado, Uncompahgre project was 130 ft. in the east heading and 350 ft. in the west heading. The advance in the east heading was through unstable ground, requiring timbering in most places. The material encountered in the west heading was dry, hard granite. During the month concrete lining has been placed in 1,000 lin. ft. of tunnel. The tunnel at the end of April was 77.6 per cent completed.

The eleven Lidgerwood unloaders in the central division of the Panama Canal, during the month of March, unloaded a total of 3,332 trains composed of a total of 58,309 cars. Of this number, 1,613 trains composed of 27,421 cars were unloaded by five unloaders at Tabernilla; 758 trains composed of 13,590 cars were unloaded by three unloaders at Miraflores dumps, and 961 trains, composed of 17,298 cars, were unloaded by three unloaders at La Boca. As all the cars were of 20-yard capacity, the material unloaded represented about 1,166,180 cubic yards.

The seven track shifting machines in the central division of the Panama Canal moved a total of 713,133 feet, or 135 miles of track during March. In the Tabernilla district track shifter No. 5 moved 227,095 feet, and No. 6 moved 140,463 feet, a total of 367,558 feet, or 69.6 miles, for the district. In the Bas Obispo district shifter No. 1 moved 71,017 feet, and shifter No. 7 moved 118,099 feet, a total of 189,116 feet, or 35.8 miles. In the Pedro Miguel district shifter No. 8 moved 69,429 feet; shifter No. 2 moved 50,808 feet, and shifter No. 9 moved 36,222 feet, a total of 156,459 feet, or 29.6 miles.

Work is well advanced on the lining of the earth section of Miraflores tunnel, and there is no doubt that the concrete will be in place before the beginning of the rainy season. The rock section has been entirely lined, and the south portal has been extended so as to hold any material that may slide down that side of the hill. As originally cut the tunnel was 600 ft. long and it is now 811 ft. long. The greater part of the additional 211 ft. representing the extension was made to hold the slide.

SUMMARY OF COST OF ROAD REPAIRS AND MAINTENANCE, 1908.—METROPOLITAN PARK COMMISSION.

			Cost Per Square Yard in Detail.							
Parkway or reservation.	Length (feet).	Width of roadway (feet).	Square yards	Labor (cents)	Broken stone (cents)	Sand (cents)	Gravel (cents.	Bituminous binder. Kind of material.	Cost (cts.)	Tot: cost (cts.)
			SURFACE TREATMENT.							
Blue Hills Parkway	15,200	26-36	46,815	3/5	..	..	..	Asphaltoilene	6	6 3/5
Middlesex Fells Parkway	7,510	30-40	28,500	1 8/10	1	..	..	Tar and asphalt	2 6/10	5 4/10
Middlesex Fells Parkway	10,535	26-36	42,178	..	..	⅓	..	Rotar	4 2/10	4½
Middlesex Fells Parkway	2,740	26-36	8,581	..	..	⅓	..	Tarine	3¼	3½
Revere Beach Parkway	3,300	36	13,767	1/10	..	2/10	..	Tarine	3¼	3½
Revere Beach Parkway	2,040	26-36	6,020	..	..	..	..	Liquid asphalt	6	6
Revere Beach Parkway	2,550	36	10,150	1	..	..	½	Liquid asphalt	6	7½
Mystic Valley Parkway	12,692	36	52,893	..	..	..	..	Tarine	3¼	3¼
Mystic Valley Parkway	2,415	40	9,521	..	..	3/10	..	Rotar	4½	4 8/10
Neponset River Parkway	2,780	26	8,034	1/5	..	..	..	Tarine	4¼	4½
Lynn Shore and Nahant Beach Drive	7,180	40	34,817	⅓	..	..	..	Cal. chloride	1 6/10	2
Revere Beach Reservation	3,519	40	13,260	2½	6 1/10	..	..	Liquid asphalt	6	9 1/10
Nantasket Beach Reservation	3,760	40	24,935	⅔	..	..	..	Cal. chloride	2¼	3
Middlesex Fells Reservation	7,860	18	15,961	..	..	..	..	Tarine	3	3
Middlesex Fells Reservation	3,010	22	7,686	⅓	..	2/10	..	Rotar	5 6/10	6 1/10
			RECONSTRUCTION.							
Middlesex Fells Reservation	6,170	18	12,340	10⅔	20½	..	27 1/10	Asphalt flux	7	65¼
Middlesex Fells Reservation	995	18	1,990	10⅔	20½	..	27 1/10		..	58¼
			RE-TREATMENT.							
Revere Beach Parkway	21,520	22-36	92,124	1⅓	1 4/10	..	..	Tarine	1 7/10	4½
Lynnway	2,365	40	10,510	1 1/10	1 9/10	..	..	Tarine	2½	5½
Revere Beach Reservation	2,481	40	9,372	..	..	..	..	Liquid asphalt	3	3
Revere Beach Reservation	4,400	40	16,620	1 7/10	1 6/10	..	..	Tarine	2 2/10	5½
			RESURFACING.							
Middlesex Fells Parkway	15,800	26-40	58,061	8½	11 2/10	..	..	Tarine and tar asp.	8¼	28

Unclassified and General Articles

Note: This section is devoted to methods and cost articles on construction work not properly coming under any of the preceding classifications.

Methods and Cost of Making 2,000 Miles of Preliminary and Location Surveys for a Railway.*

The following paper is not a theoretical discussion of railroad location. It is intended to give a general description of some extensive railroad surveys, a brief outline of methods and results, and the cost per mile. The writer does not remember having seen a similar statement covering so many miles, viz. 1,400 miles of preliminary lines and 600 miles of location, and therefore trusts the paper may prove of value. The surveys were completed some time ago, at which time the tables of mileage and cost were prepared, but not heretofore published.

Methods Used.—Field parties were made up as follows:

	Monthly Salary
Assistant Engineer in charge	$[illegible] to $1[illegible]
Transitman	[illegible] to [illegible]
Leveler	[illegible]
Rodman	[illegible]
Head chainman	[illegible]
Rear chainman	4[illegible]
Back flagman	[illegible]
Stakeman	[illegible]
Axemen (from two to four)	30
Topographer	6[illegible]
Teamster (team)	4[illegible]
Draftsman (part time)	6[illegible]

Camp outfits were not used. The parties boarded at houses along the line. This was often a disadvantage on account of difficulty in getting quarters, especially for a full corps; but, on the other hand, the party could frequently make its headquarters at some town and drive to and from the work, so that probably this method served just as well as furnishing camp outfits.

Each party was given from [illegible] to 60 miles of line to cover, depending on local conditions. The following abstracts from the "General Instructions" give an idea of the work required to be done by each party.

The Assistant Engineer will receive instructions as to where and where preliminary lines will be run, grades required to be used, what the line is intended to develop and the general information necessary in regard to the same. He will then be responsible for the amount and character of the work done by his party, and for the proper development of the country over which he works.

Topography will be taken on lines as instructed.

(Topography was taken on practically all lines except [illegible].)

After preliminaries are run, the Assistant Engineer will be instructed over which line to locate.

All location will be first projected on topography sheets, etc.

No location will be considered as final until [illegible] and revised, if necessary, by the Assistant Chief Engineer, and [illegible] by the Chief Engineer.

The Assistant Engineer was not expected to spend all his time with the party, but to be with it enough to see that work was going on satisfactorily and that lines were being run over the proper routes, the remainder of his time was spent in a thorough study of the country, getting out routes to be examined, and looking after his necessary office work and correspondence. On location and in particularly difficult country he was to be with the party almost constantly.

After the first route to be examined had been chosen, a preliminary line was run through, then the alternate routes were run, all surveys being tied together, and finally the lines required for a thorough development of all possible routes were run. Although the first preliminary line might give the grades and curves desired, and possibly be the line over which the final location was made, it was not finally determined on until the subject was fully investigated.

Sometimes all the preliminary data required over a certain route may be obtained quickly by stadia methods, but some sort of a definite line is required from which reliable conclusions can be drawn. Especially is this true in heavily timbered hilly country, where the range of vision is very limited and traveling on foot is excessively wearisome, and unless such a method is used some feasible route is very likely to be overlooked. Many times on these surveys the Assistant Engineer was sent back over parts of the line to hunt out something better, quite often with success.

In locating long grades it was preferable to start at a summit and run down hill. With a little experience the Assistant Engineer could make a sufficiently close estimate of the amount to allow for compensation for curvature, and could run his line accordingly. In the mountainous part of the country here described this compensation amounted to about 6 ft. per mile, equal to 0.12 per cent grade, and preliminaries for a 1.0 per cent compensated grade run on [illegible] per cent straight grade gave the desired information.

In case of the choice of two apparently equal routes, a location was made over each, and estimates were prepared for comparison before choosing a line. In following the larger watercourses it was usual to locate a line on either side for purposes of comparison, and in order to determine

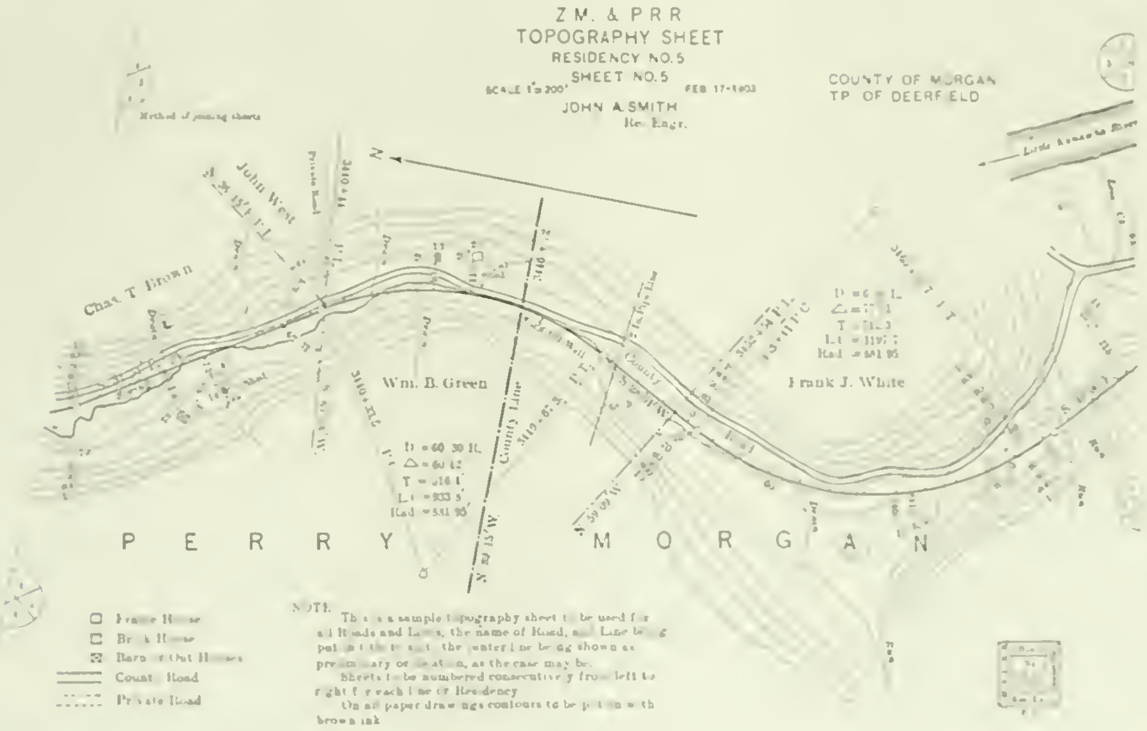

Fig. 1—Standard Topography Sheet.

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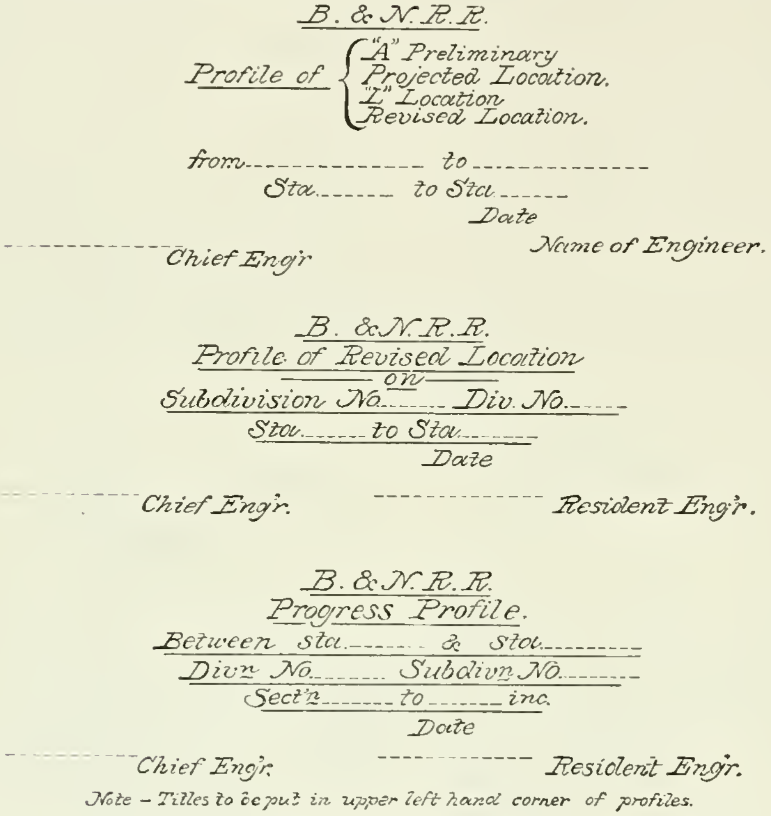
*Condensed from a paper by W. [illegible] Mc[illegible]ridge published in the Proceedings of the American Society of Civil Engineers for April, 1909.

the advisability of crossing from one side to the other either to get a better line or to block the country against rivals.

Some branch lines were located, and quite an extent of line was located and afterward abandoned by reason of change of plans, but at the conclusion the miles of line actually footed up one-third more (this is practically the correct proportion, but it varied a little more or less on different divisions) than would be required on the entire layout. This extra location was partly for comparison, but largely for reasons mentioned later. In addition to this, many miles of paper location, not located on ground, were made for the same reasons.



B. & N. R. R.

Profile of { "A" Preliminary
Projected Location.
"L" Location
Revised Location.

from ------ to ------
Sta. ------ to Sta. ------
Date
------ Chief Eng'r Name of Engineer.

B. & N. R. R.
Profile of Revised Location
on
Subdivision No. ------ Div. No. ------
Sta. ------ to Sta. ------
Date
------ Chief Eng'r. ------ Resident Eng'r.

B. & N. R. R.
Progress Profile.
Between sta. ------ & sta. ------
Div'n No. ------ Subdiv'n No. ------
Sect'n ------ to ------ inc.
Date
------ Chief Eng'r. ------ Resident Eng'r.

Note — Titles to be put in upper left hand corner of profiles.

Fig. 2—Standard Titles for Profiles.

It may appear to some that there was much unnecessary location and running of preliminary lines, but in rough country like this, and on work of this magnitude (in 220 miles of this line were 21 tunnels, the longest being 4,000 ft., five viaducts from 400 to 1,000 ft. long, and more than 100 ft. in height, besides numerous other bridges), it is time and money well spent. In no other way can the exact data be gotten, and it leaves no question as to the available routes and the grades obtainable.

The locating engineers, or others on the ground, may feel certain that a line is not feasible, but it is hard to furnish proof, both to himself and to others who are interested, but who will never be over the ground, that such is the case, except by map and profile. Again, an apparently hopeless line may show up much better than expected, and *vice versa*. In this the writer must not be misunderstood to mean that anyone can get the best location if he only runs lines enough; such is far from the case; lines can be run indefinitely without securing the desired results, unless the proper judgment and knowledge are combined with them, the location being usually the most difficult problem of railroad work. What is meant is that it is necessary to run a sufficient number of lines, preliminary and location, to arrive at correct conclusions and to get the requisite exact data to prove the conclusion.

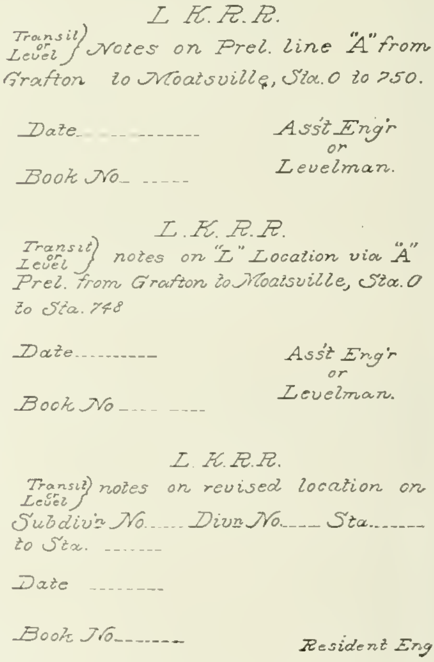
Topography, showing contours, houses, roads, watercourses, etc., etc., was taken on practically all lines. This was taken on 12x18-in. sheets. The transit line was plotted each day on the requisite number of sheets; a light pencil line, at right angles to the center line, was drawn through each station for ease in plotting the topography; elevations were marked at each station; the stations where contours crossed the center line were determined from the profile and marked; connections to other sheets were shown, and then the sheets were ready for field use. The lines were plotted to a scale of 200 ft. to 1 in. The topography was plotted in the field. A hollow drawing-board, 18x24 ins. was used. The sheet in use was tacked to the board, and the additional sheets were carried inside. A strap around the shoulders of the topographer served to carry the board, and formed a support while plotting (Wellington's method).

This method was preferred to any other; it is quicker; saves much copying and plotting; the work can be plotted better in the field, where everything can be seen at the time of plotting; and at night the Assistant Engineer has a finished map to look over and study. The topography was taken accurately by using a metallic cloth tape for distances and a hand-level for elevations. Only in this way can one get a projected location to correspond closely with the actual one. The topography was ordinarily taken for 300 ft. on each side of the center line; at particularly difficult summits or similar places a strip from 1,000 to 2,000 ft. wide was often shown, the necessary topography being obtained by auxiliary lines. The sheets were inked in each night.

To obtain a large general map showing all lines, the lines were carefully plotted on tracing cloth, the small sheets were fitted so as to make the center line on each sheet fit the center line on the tracing, and then the topography was traced. By this method any error in plotting or joining the small sheets was eliminated from the large map. This tracing, from which blue prints were made as required, was retained in the office, the sheets being used for rough work and field use.

The location was projected in pencil on sheets in the usual manner, care being taken to determine all angles between tangents by the calculated courses from each sheet, not by using a protractor, or by measuring intersection angles, although either might be used as a check. After the line was located on the ground, the location was accurately tied to the preliminary line and replotted on sheets; the pencil projection was then erased, if so desired.

In staking out the location, the aim was to get a profile to correspond with the projection, and not to get the lines in exactly the same relative positions shown by the projections. The lines always varied more or less in their relative positions. Also, it was often found desirable to change the location at places, giving a corresponding change in the profile; for instance, it might be decided in the field that, owing to surface conditions, certain hills could be hit harder or perhaps avoided. The most frequent change was to put the line harder into steep side-hills. When projecting lines along such places, there is nearly always a tendency to fit the line too closely to the surface and not to allow enough cutting to put the roadbed on firm ground. Owing to these facts, it is usually better to have the first location projected and run in by the field engineer, who is most familiar with actual conditions; after that the revisions and necessary changes can be taken up by the higher



L. K. R. R.
Transit or Level } Notes on Prel. line "A" from Grafton to Moatsville, Sta. 0 to 750.
Date ------ Ass't Eng'r or Levelman.
Book No. ------

L. K. R. R.
Transit or Level } notes on "L" Location via "A" Prel. from Grafton to Moatsville, Sta. 0 to Sta. 748
Date ------ Ass't Eng'r or Levelman.
Book No ------

L. K. R. R.
Transit or Level } notes on revised location on Subdiv'n No. ------ Div'n No. ------ Sta. ------ to Sta. ------
Date ------
Book No. ------ Resident Eng'r

Fig. 3—Standard Title for Field Books.

officers. Projections made by anyone not thoroughly familiar with the ground should be used with caution. The best location cannot be obtained without the topography and a projected line; also, it cannot be obtained on the sheets alone, without a thorough and complete knowledge of the character of the country; the two must be studied together, the field engineer at all times corresponding freely and fully with the Chief Engineer and getting his ideas and instructions.

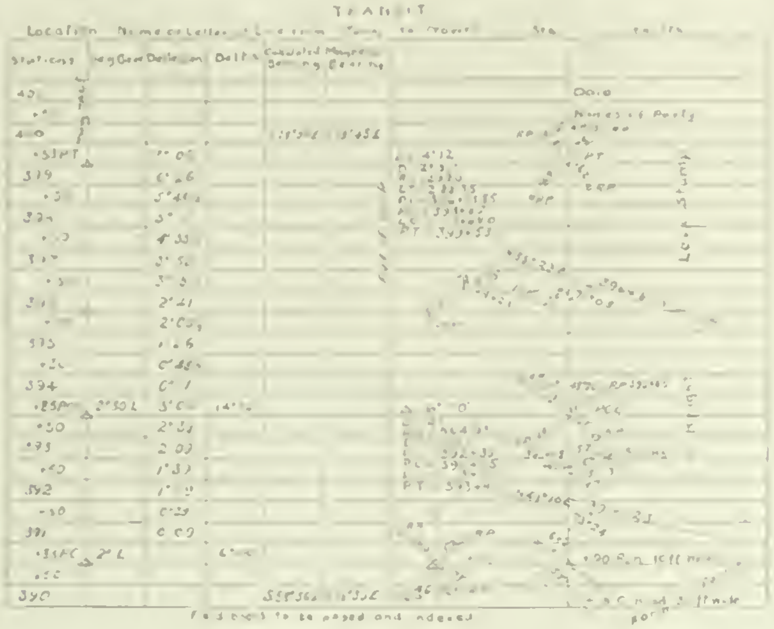

TRANSIT
Location Name or letter of Line from (Town) to (Town) Sta. to Sta.
Stations
Deg. Curve Deflection
Delta
Calculated Magnetic Bearing
Date
Names of Party
Field notes to be paged and indexed

Fig. 4—Standard Form for Level Notes.

After the first location had been made, it was studied further in the Chief Engineer's office; if any changes were desired they were taken up with the Assistant Engineer, usually by the Assistant Chief Engineer and the Assistant Engineer going over the ground together and there studying the question. After settlement, the location was taken as final for that route, and the maps and plans were brought up to date.

Standards.—All curves of 3° or more had spiral approaches. These were allowed for in cross-sectioning by offsetting the slope stakes the required distance. The spiral was in standard form, so that when the degree of curvature was known, the offset from the simple curve and the length of the spiral were obtained from tables. For simplicity and ease, all records, profiles, etc., were kept on simple curve data. When spiral curves came in tunnels, a special plan was made for each case showing the offsets from the tangent and the simple curve at every 10 ft. on the spiral, the alignment being kept on the tangent and the simple curve, and allowing the required offset in giving the widths for the tunnels. All grades were compensated 0.04 ft. per degree of curvature.

Vertical curves were inserted at all places when the change of grade was more than 0.1 ft. in 100 ft., a standard form being used in which the length of the vertical curve varied directly with the change of grade.

The usual weekly reports, maps and profiles were sent in by the Assistant Engineers. Standard forms were used for all notes, maps, profiles, plans and reports. The standard rules were first issued as typewritten copies, and standard forms were adopted from time to time as needed. Later they were printed and issued in book form, being bound up with 22 pages of general rules and information, together with 21 standard forms for notes and plans. It was found to save much work and time in the Chief Engineer's office to have all these in uniform shape, much correspondence was likewise avoided, as employes could readily find sizes, scales, etc., for plans, and also other information. Therefore they were not compelled to write to headquarters, and thus avoided the delay of two or three days required for letters to go and come.

A few of the standards used extensively on location are here shown.

Figure 1 shows the standard topography sheet, the same form being used on preliminary and construction lines. After the line was finally determined, sheets were prepared showing the line only, and the titles were made to suit the construction work shown.

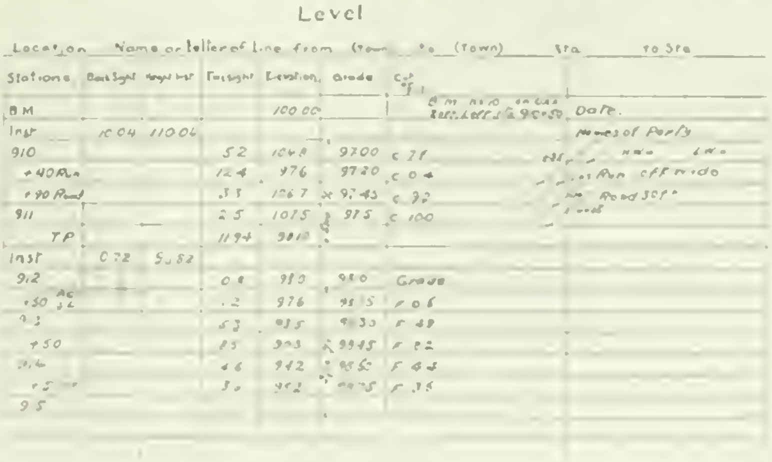


Fig. 5—Standard Form for Transit Notes.

The standard titles for profiles are shown by Fig. 2 and the standard titles for field books by Fig. 3. The standard forms for transit and level notes are shown by Figs. 4 and 5, respectively. Fig. 6 shows the standard form for a location profile and Fig. 7 shows the standard form for a location survey for a bridge. When first prepared the structure was drawn in pencil, and was not inked in until the detailed design had been made by the Consulting Bridge Engineers, A. P. Boller and H. W. Hodge, M. Am. Soc. C. E. The standard form of report of openings required is shown by Fig. 8.

Cost.—The greatest number of miles of preliminary line run in one day by one party was 7, and of location, 1½. The location averaged slightly more than 1 mile per day per party, except on two lines where it averaged ¾ mile. Stakes were set every 100 ft. on tangents, and every 50 ft. on curves. Special pains were taken with the instrument work and measurements in order to avoid the chance of serious errors in the center line after construction commenced. The speed of location parties was usually limited by the amount of clearing that could be done, but the number of curves and the rough character of the ground were also large factors in limiting the speed.

Each party cost from $35 to $40 per day, being allowed all expenses in addition to salaries.

Table I gives the cost per mile of the completed surveys. It is to be noted that this is the total cost, and includes office rent, purchase of instruments and supplies, general expenses, all salaries, field expenses, and the preparation of final maps, plans, profiles, and estimates, with everything in readiness to make contracts for the line.

Column 7 gives the cost per mile of actual location, including preliminary lines. Columns 3 and 4 show that there were from 2 to 5 miles of preliminary lines run for each mile of location, except on one line. Table I also includes 302 miles of check levels, the cost being distributed among the various accounts. The data for the Parkersburg Bridge and Terminal line include surveys and soundings for the Ohio River Bridge. The cost per mile includes the topography on practically all lines, except one where it was taken only on the located lines.

The cost shown in Table I being the total charge against engineering from the inception of the project to the beginning of construction, contains a few items which might well be charged to other accounts than location. Instruments purchased would be a credit; some elaborate property surveys and bridge surveys could be charged to construction, but they probably are not large enough to have much effect on the cost per mile. If taken into account,

TABLE I.

Company— (1)	Amt. Spent. (2)	—Miles of Surveys.— Preliminary. (3)	Location. (4)	Total. (5)	Average cost per mile. (6)	Av. cost per mile of location. (7)
L. K. R. R.	$25,076.83	428.19	193.85	622.04	$40.31	$129.36
Z. M. & P.	19,812.77	509.03	105.23	614.26	32.25	188.28
B. & E. R. R.	20,466.68	241.75	113.70	355.45	57.58	180.00
P. B. & T. R. R.	6,651.98	84.56	38.17	122.73	54.20	174.28
B. & N. R. R.	19,249.94	162.51	151.29	313.80	61.34	127.23
Totals	$91,258.20	1,426.04	602.24	2,028.28	$45.00	$151.53

they would reduce the cost. The cost on the Little Kanawha and on the Burnsville & Eastern Division was increased considerably owing to much work being done during a bad winter, when the weather was very unfavorable. The cost on the Parkersburg Bridge & Terminal line was increased by a large amount of property surveying in the city, and by the surveys for the bridge.

The cost on all the West Virginia lines was increased by the immense amount of chopping and clearing necessary. When mountain laurel was encountered, all the axemen that could be worked could not keep a location party moving.

The influence of the weather is a large item in the cost of these surveys; a line run in the middle of winter may easily cost one-quarter more than if run during more favorable weather.

The average cost of one mile of preliminary or location survey, determined from a detailed study of the daily reports of field parties, of office work done, and similar data, is shown by Table II (to the nearest dollar), and is believed to be very close to the actual figures.

TABLE II.

Company—	—Average Cost of One Mile.— Of preliminary.	Of location.	Of locat'n, including preliminary.
L. K. R. R.	$25	$ 74	$99
Z. M. & P. R. R.	23	79	102
B. & E. R. R.	35	105	140
B. & N. R. R.	31	94	125

The figures in Table II include all expenses, as in Table I.

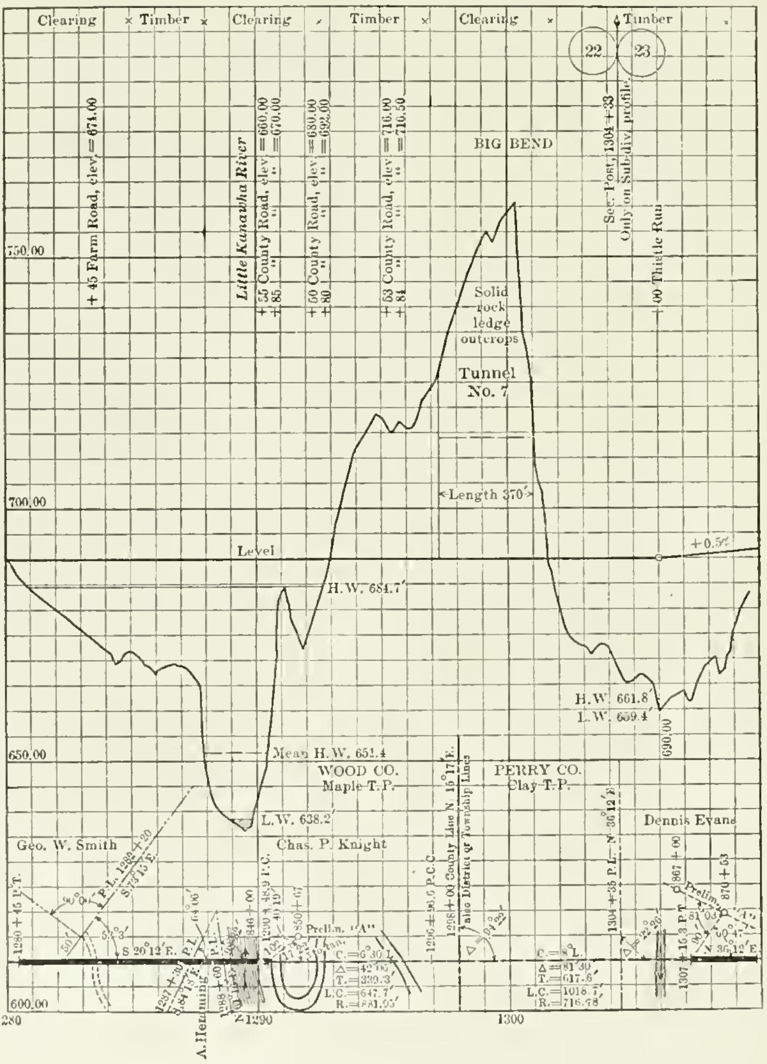


Fig. 6—Standard Form for Location Profile.

Table I shows a large variation in the cost of surveys on different divisions, the cost varying from $128 to $188 per mile, with an average of $151. On the assumption that lines located for comparison or similar purposes should be included in the average, one-third should be added to these amounts, as previously noted; the cost would then be as follows:

Low	$171 per mile
High	251 per mile
Average	202 per mile

Throwing out of the account the mileage of abandoned lines, branch lines, etc., and charging the entire cost to the main line, terminus to terminus, would give

$$\frac{\$91{,}258.20}{328}=\$278.23$$

per mile, which would be rather expensive. This, however, is not a fair assumption, and should not be considered, because many miles of lines not needed to determine the main line were located for other reasons and purposes. Therefore, the plan of throwing out only duplications, for comparisons, as shown in the preceding paragraph, gives the correct average cost per mile for the development of the country, including actual comparative locations where needed. It should also be borne in mind that a large proportion of this duplication was necessary, owing to the laws of West Virginia, which require an actual line, located on the ground, and a complete map and profile of that line to be filed with the Secretary of State, and at the county seat, before a railroad company has any rights, of priority or otherwise, to that route or line. This required complete locations for all proposed branch lines, a large number of which were located, and also a complete location over any route for which it was desired to obtain rights. For these reasons, the lines located account for the excess of the mileage over the actual length of the main line.

On the basis of Table II, it may be assumed that, where the route has been previously determined within such narrow limits that the preliminary and location lines are of equal length, the surveys will cost from $100 to $140 per mile. This is borne out by the results on the Buckhannon and Northern line where the location and preliminary lines were practically equal and the cost was $127 per mile.

These two statements may be combined and put in the following form:

To locate one mile, including an equal length of preliminary lines, cost from $100 to $140; average	$115
To locate one mile, final location, including from two to five times as great a length of preliminary lines, cost from $128 to $188; average	151
To locate one mile, final location, including from two to five times as great a length of preliminary lines, and one-third of a mile of location for comparison, cost from $171 to $251; average	202

A tabulation of the mileage of the Buckhannon and Northern line, with reference to the actual length of line to be built, and showing how the results agree with the averages deduced from Table I, is as follows, the Buckhannon and Northern line being used because the conditions there make it the best average of "all conditions" encountered on the various lines.

Total miles located		151.29
Miles of main line contracted for	80	
Miles of main line not contracted for	4	
Miles of connecting line located, but which may or may not be built, about	26	110.00
Making actual miles	110	
Leaving duplications, comparisons, etc.		41.29

110 miles cost $19,249.94 = $175 per mile.

Results.—The results obtained by studying and surveying the neighboring country, will amply justify the initial cost, and, without doubt, the final results will prove that it is cheaper in the end. A few thousand dollars judiciously spent on surveys will be more than made up for in construction, not only in the actual cost, but in a better line.

That the desired results seem to have been obtained, may be shown briefly as follows:

1. **Easiest grades; 0.5 per cent west. 1.0** per cent east (all the latter in the 25 miles

near the eastern end), other roads using 1.[illegible] per cent.

2. Curvature 8° maximum as against 12° on other roads.

3. Short line. This is seen best on the map. The Little Kanawha line is [illegible] miles shorter than the river, the only water route. The Ohio line is 16 miles shorter than the existing lines between termini.

4. Occupation of critical points: Another line since built through the Burnsville and Eastern Division (the Burnsville & Eastern line never having been constructed) and a few miles of Little Kanawha located, had to locate on and occupy this line for about 15 miles, although [illegible] and 12° curves. It could not have been built for its present cost without making arrangements with the Burnsville & Eastern and Little Kanawha railroads.

5. The definite places previously determined on were, of course, reached.

6. It being decided, after some surveys, by which the advantage of this line proved so apparent—to build the line as described, no complete estimate of the cheapest possible line in first cost was prepared, but a sufficient number of estimates were made to assure that the [illegible].

All the work was carried out under S. D. Brady, M. Am. Soc. C. E., then, as now, Chief Engineer of all these companies, who gave much personal attention to the work and to whom the writer is indebted for assistance and information in preparing this paper, and for permission to publish the maps and costs.

The writer was Assistant Engineer on the Little Kanawha Division, in charge of [illegible] to completion he became Assistant Chief Engineer of all the companies, both on location and construction.

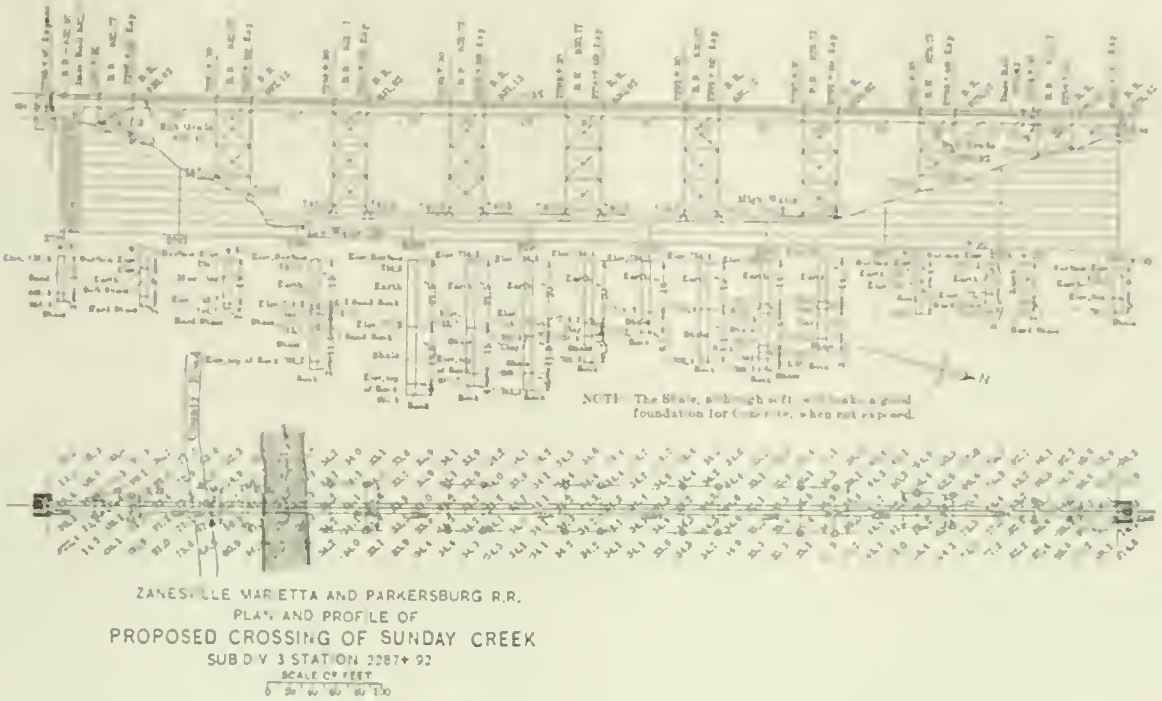
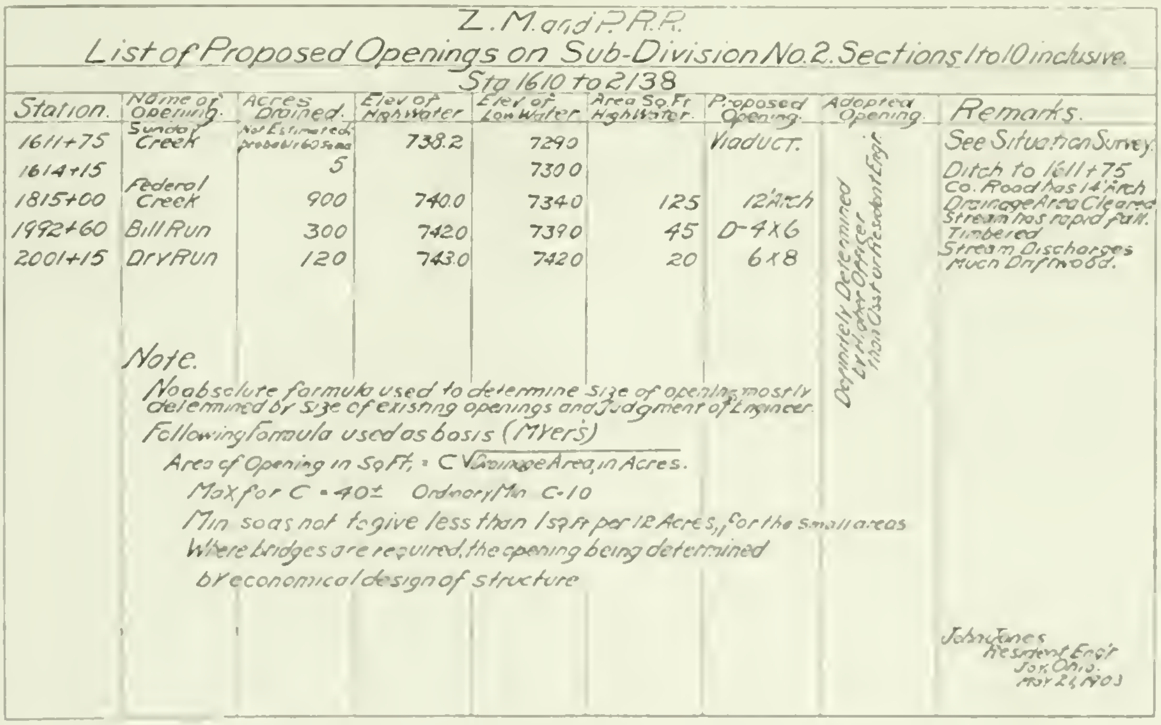

NOTE: The Shale, although soft, will make a good foundation for Concrete, when not exposed.
N
ZANESVILLE MARIETTA AND PARKERSBURG R.R.
PLAN AND PROFILE OF
PROPOSED CROSSING OF SUNDAY CREEK
SUB DIV 3 STATION 2287+92
SCALE OF FEET
0 20 40 60 80 100
Chief Eng'r

Fig. 7—Standard Form for a Situation Survey for a Bridge.



Z. M. and P. R.R.

List of Proposed Openings on Sub-Division No. 2. Sections 1 to 10 inclusive.

Sta 1610 to 2138

Station.	Name of Opening.	Acres Drained.	Elev of High Water	Elev of Low Water	Area Sq. Ft High Water.	Proposed Opening.	Adopted Opening.	Remarks.
1611+75	Sunday Creek	Not Estimated, probably 60 Sq. mi	738.2	729.0		Viaduct.	Definitely Determined by Higher Officer than Chief or Resident Engr.	See Situation Survey.
1614+15		5		730.0				Ditch to 1611+75
1815+00	Federal Creek	900	740.0	734.0	125	12' Arch		Co. Road has 14' Arch Drainage Area Cleared
1992+60	Bill Run	300	742.0	739.0	45	D-4×6		Stream has rapid fall. Timbered
2001+15	Dry Run	120	743.0	742.0	20	6×8		Stream Discharges Much Driftwood.

Note.

No absolute formula used to determine size of opening mostly determined by size of existing openings and Judgment of Engineer.

Following formula used as basis (Myers)

Area of Opening in Sq Ft, = C $\sqrt{\text{Drainage Area, in Acres.}}$

Max for C = 4.0± Ordinary Min C = 1.0

Min so as not to give less than 1 sq ft per 12 Acres, for the small areas

Where bridges are required, the opening being determined by economical design of structure

John Jones
Resident Engr
Jay, Ohio.
May 21, 1903

Fig. 8—Standard Form for Report of Openings Required.

The Development and Use of Steel Sheet Piling, with Some Data on the Preservation of Steel Buried in the Ground.*

Considering that sheet piling has always been such an important tool and that so much often depends on its ability to resist heavy pressures, it is indeed remarkable that no material improvement was made until within recent times. While it is true that certain forms of interlocking cast-iron piling were devised and tried almost a century ago, and although more or less of this has been used since then, it is only within the last nine years that improved sheet-piling has been produced commercially and that its application has become general.

The first practical application of cast-iron sheet piles seems to have been made by Mr. Mathews in the construction of the north pier of Birdlington harbor in Yorkshire, England. This harbor, like so many on the coast of England, is enclosed by two stone piers, and the cast-iron sheet-piling was used in the foundation of the head of the north pier. In this case, sheet-piles of a section somewhat similar to that of the present United States piling were used. The piles were 21 ins. to 2 ft. wide and about 8 to 9 ft. long.

Later on, about the beginning of 1822, a type of cast-iron sheet-piling was patented by Mr. Ewart. These piles were to be made about 15 ins. wide and from 10 to 15 ft. long, especially for cofferdam work. This type of cast-iron piling was used with complete success in a cofferdam of considerable size in the River Thames. It was also used to advantage in piers and walls of docks at Liverpool.

The cast-iron piles, patented by Mr. Ewart, and those used by Mr. Mathews, were really interlocking piles and it must be admitted that some of the steel piles patented in the last few years cannot be considered as being improvements on these early forms, except in the difference in the metal used.

In 1824, cast-iron sheet-piling was again used in the foundations of the quay wall of Downes' wharf near the London docks. In this case the piles were not interlocking, but merely overlapped each other at the joints.

Later on a work, on a much larger scale than those mentioned previously, was executed. This was the construction of about 2000 ft. of wharf at the sea entrance of the Norwich and Lowestoft navigation, in which cast-iron sheet piles of T-shape without interlock were used. In order to keep the piles in alinement a pair of wrought iron plates projecting outwardly was riveted to each sheet-pile near the bottom, and formed a sort of guide which prevented the lateral displacement of the piles while being driven. This work was completed in 1832 and it is interesting to note that it appears to be the first time that cast-iron sheet piling was driven in lengths over 15 ft. The piles used were 30 ft. long and it speaks well for the quality of the metal and the care taken in driving to know that this installation was very successful.

In 1833-34 another large piece of work was done with cast-iron sheet-piles. This was the construction of the Brunswick wharf on the River Thames. The sheet-piles were 1 in. and 1¼ ins. thick and the weight of each was about 1700 lbs. The length of the wharf was 720 ft. and more than 900 tons of cast-iron piling was driven.

Wherever this cast-iron piling was driven great care had to be taken in handling this material, owing to its brittleness. The piles were generally driven by keeping the heads protected with blocks of wood to distribute the blow of the ram and prevent the battering of the pile. Rams weighing from 300 to 1500 lbs. were employed and the same were operated with falls not exceeding 4 ft.

In view of the apparent success that attended the use of cast-iron sheet-piling, it was remarkable that other forms of metal sheet-piling were not devised, especially such as could have been made from standard iron shapes. Although it is known that wrought-iron sheet-piling was used later extensively, not much is known of its actual application or details. Some of it was formed of flat boiler plates with vertical Tees riveted to them. There were no interlocking means provided.

It seems that the first attempt to form steel sheet-piling from structural shapes was made by a German inventor, August Simon, in 1893, during which year he secured a patent in the United States. The Simon steel sheet-piling was of the box form, that is to say, it was composed of two I-beams or channels spaced with separators and arranged so that a single channel or I-beam could be driven in the two longitudinal slots left between the flanges of the pair of beams. It appears that Mr. Simon used this piling in sinking a number of shafts in Germany.

In 1901, Mr. George W. Jackson of Chicago patented an interlocking piling very similar to that invented by August Simon, which he used successfully in the construction of two cofferdams for the foundation of the Randolph Street Bridge across the Chicago river.

It is interesting to know that the improvement of the Chicago River may be taken as the main cause of the introduction of steel sheet-piling for cofferdams in deep water. The narrowness of the river flanked by high buildings made it very difficult, if not impossible, to drive and brace cofferdams of wood-sheeting.

The first installation of the Jackson piling demonstrated the fact that some modification was necessary to improve on the water-tightness of the sheet-piling. The space between the double beams had to be packed with clay in order to make this sheet-piling tight. To overcome this defect, a modification of this piling was devised wherein the space between the double channels was filled with wood before the two beams were bolted together. This proved satisfactory, but, at the same time, the cost of this type of piling was excessive.

The principal defect, however, of the double beam type of steel-piling is that its weight is above that absolutely necessary. It was to overcome this objection and, at the same time, to provide a steel-piling that would be watertight without clay or wood caulking that Mr. Luther P. Friestedt of Chicago invented the interlocking channel-bar piling. The first of the Friestedt piling was driven in October, 1902, in the mine shaft of the Johnson City & Big Muddy Coal & Mining Co. at Johnson City, Ill. Since then the Friestedt piling has been used in increasing quantities until thousands of tons are sold yearly. The Jackson and Friestedt piling were the only two types of the fabricated beam forms that were ever used extensively and satisfactorily.

It was, of course, soon evident that a very desirable form of piling would be one that could be rolled directly in the steel mill and which should be complete in itself. Some shapes were patented with this idea in view, but this type of piling was not rolled successfully until a special method of rolling had been devised. Although the one original form of rolled piling was patented by Samuel K. Behrend, in 1899, it was not until December, 1904, that this piling was rolled successfully. This is the so-called United States piling and I understand that, at the present time, most of the piling sold by the manufacturer, who also controls the Friestedt patents, is of the United States type.

We have thus far considered two of the principal types of steel-piling and, as you will recollect, one is made from structural shapes, while the other is rolled complete in the mill. The principal defect of these types is the limitation in sizes and weights that can be obtained, and for this reason the use of plates especially commends itself. Although various forms of steel piling made from plates were patented some years ago, no steel-piling of this type was made until October, 1907, and it was the first time driven Nov. 16 of that year at Berrien Springs, Mich. This piling was made from corrugated plates arranged with riveted continuous locking clips and was of the form patented by Messrs. L. R. Gifford and R. V. Sage in 1904. This test demonstrated that the idea of using plates for making steel piling was entirely practical and economical and further trials have amply demonstrated the advantage of plate-piling. It has been stated that thin plate-piling could not be driven successfully without some form of follower that would go down with the sheets and which would afterwards be pulled. This, however, has never been found necessary with corrugated steel-piling, and it will interest you to know that, in driving piling of this type only ⅛ in. thick, a 700-lb. steam hammer was kept striking on top of the piling for more than one hour at a time. This did not even make a perceptible indentation in the piling, although the only thing interposed between the hammer and the piling was a driving cap of soft iron. Not even a wood cushion was used.

No steel piling now on the market fulfills all the ideal conditions required of this material, but it appears that corrugated plate-piling combines more desirable features than any other type. It may not be amiss here to call attention to the principal requirements of steel sheet-piling.

While a steel pile is being driven, it is subject to the conditions of a column loaded at both ends, one end load being the resistance of the ground, the other being the force of the hammer. It is at this time, particularly, that the steel sheet-pile is subject to its most severe duty, and then stiffness is paramount. In fact, the greater the stiffness, the easier it will drive, because all the force in the blow of the hammer is usefully employed. If the sheet-pile has not the required stiffness it will soon buckle in any kind of hard soil, and then most of the force in the blow of the hammer is spent or absorbed in increasing the distortion of the sheet-pile and in overcoming the resulting friction between the contiguous sheet-piles. That this feature of stiffness cannot be emphasized too strongly has been well proved by numerous failures of steel-piling formed of sections weak in this respect, whether these sections are used alone or in connection with very stiff members.

The next important requirement of a satisfactory steel sheet-piling is that it shall form a wall of shoring wherein the members act in unison, otherwise there is a mass of superfluous metal which does no work and must be supported by bracing, together with the material, soil or water which it is supposed to carry. It is more important to have steel piling sections which lock rigidly together at least in one direction than to have sections which allow of being deflected either way, because as a rule, the steel piling is driven in straight lines and for sharp corners special sections are necessary anyway. When the interlocking is loose in both directions it is almost impossible to drive the individual piles in a straight line and the result is a sheet-piling wall which bears heavily and very unevenly against the wales or bracing required to hold it up.

---

*A paper read before the Technical League, New York City, April 30, 1909, by J. R. Wemlinger, C. E., President, Wemlinger Steel Piling Co., 11 Broadway, New York.

However, no matter how much care is taken in its manufacture or whatever may be the superiority or excellence of its design, steel sheet piling, like any other engineering material, must be used with intelligence and judgment. If so used, steel sheet piling is, undoubtedly, the most satisfactory material for the installation of foundations of all kinds. Considering the certainty of results, as well as the economy of the method, there is no better or cheaper method of constructing column footings, bridge piers or the like, than the open air method. All the work is done without discomfort to the workmen and inspection is always easy and convenient. With the proper steel sheet-piling used with care, the open air method can be employed in construction work which, heretofore, required a much more expensive system. That this is being appreciated by engineers and contractors is amply demonstrated by the fact that steel sheet-piling is being specified and used in increasingly large quantities, and I know of many cases where it was given the preference after a most careful investigation of other methods.

Although metallic sheet-piling has always been made from steel in the United States, it will interest you to know that cast iron sheet-piling is still being used elsewhere. In the construction of the Isna Barrage across the Nile, the foundations of the dam were on wet running sand and cast iron sheet-piling was driven so as to enclose completely the area covered by the structure. The piling was of the ordinary tongue and groove type driven about 11 ft. into the river bed, after which the joints were grouted. It may be mentioned that each cast iron pile weighed 3184 lbs. and the 13,950 tons of piling was used on the Isna Barrage.

It has been stated that steel sheet piling has often been used as a part of permanent structures, and the question naturally arises: What is the life of the steel sheet-piling embedded in the ground? In order to be able to fully answer this question, it is necessary to consider the various conditions that affect the durability of iron or steel in this case, such as the nature of the soil and the composition of the metal itself. To discuss these features fully would prolong this paper beyond reasonable time, but the subject is of such importance as to deserve much more than a few passing remarks.

In the first place, it must be remembered that iron or steel will not corrode in air unless moisture is present, nor will it corrode in water unless air is present. Deep down in the ground the amount of air dissolved in the water is almost nil, and it is only near the surface that the ground water contains free air and carbonic dioxide carried down from the upper layers.

There is every logical reason to believe that steel embedded in the ground or left in contact with standing water will be preserved indefinitely. However, it is appreciated that, no matter how much good evidence may be in favor of this conclusion, practical experience will have greater influence. It is fortunate that we can point to actual cases that seem to confirm this logical reasoning.

There is in the possession of one of the New York Gas Companies quite a number of different articles of iron and steel that have been unearthed from time to time while excavating for laying gas pipes. Among these are arms and implements that were found in lower New York and proved to have been originally in the possession of British soldiers. Inasmuch as the British troops sailed away from New York on November 25, 1783, it follows that the articles are now at least 125 years old. While pretty well rusted, these things are by no means entirely destroyed as would be expected. As a matter of fact, it is believed that most of the rusting occurred before the implements were completely embedded, and it is obvious that for some time these articles must have been lying very near the surface, if not altogether exposed.

I have also seen a piece of gas pipe 2 ins. in diameter that was taken up after it had been in the ground for 20 years. This is in such excellent condition that it is impossible to detect any effect of corrosion. The original mill scale is intact, and, in fact, the appearance of the pipe is such that, except for the thin coating of earthly matter, it has all the appearance of a pipe fresh from the mill. It is the most remarkable evidence of the durability of iron or steel embedded in the ground that I have ever seen.

At a meeting of the Engineer's Society of Western Pennsylvania, held recently, during which the question of corrosion was fully discussed, Mr. R. B. Woodworth made the following remarks:

> "It may be interesting to state that I have in my possession a piece of iron that was put into the Mississippi River in the year 1862 and that is to-day in as good condition as when it was put in. It was painted with some kind of red paint which looks very much like red oxide of iron, and the paint is just as good to-day apparently as it was the day it was put in. The conditions there must have been extremely favorable to its preservation. The water of the Mississippi River at that point is probably pure and the iron was buried in the Mississippi River silt, sand or gravel so as to be protected from exposure to atmospheric conditions, and as a consequence there was nothing to make corrosion."
>
> "I have also a theory that so far as our own rivers are concerned, although they do carry a great deal of free acid, yet when the steel is placed sufficiently below the river bed as to get the advantage of the filtering action of the sand and gravel, we do not have to do with an acid laden condition, but rather with the condition of practically pure water free from contact with air, and I think we have every assurance to believe that the life of steel under such circumstances will be indefinite. I was told by the engineers who have charge of the construction of the Black Rock Lock at Buffalo that the waters of the lake are not considered in any way dangerous and that steel of ordinary commercial quality in such installations may be expected to last for any reasonable length of time."

Further evidence of the durability of iron and steel embedded in the ground is found in the Proceedings of the American Society of Civil Engineers, Nos. 6 and 7 for the year 1907. At the Annual Convention held at Mexico City July 10, 1907, among various subjects for discussion was the following: "Will iron or steel used in foundations, independently or in combination with other materials, last indefinitely when in direct or indirect contact with water?"

The most interesting contribution to this discussion was undoubtedly that presented by Mr. John F. O'Rourke, the well-known foundation engineer and contractor. Mr. O'Rourke stated that:

> Iron and steel used in foundations, apart from conditions where electrolysis may occur, last indefinitely when in direct or indirect contact with water, provided the water remains unchanged. The reason for this is obvious. Water attacks iron or steel on account of the oxygen it contains, and, if this is a proportionately small quantity, the amount of oxygen contained in wet concrete or ground is negligible and, having once been exhausted, the metal remains unimpaired and protected.
>
> The writer has seen many cases where immersion in standing water has been a matter of years, and in every case the effect upon the metal has been no greater than if it had stood for the same length of time in linseed oil. In one case bolts on the inside of cast-iron cylinders, filled with concrete, were exposed to the salt water in the Harlem River for more than thirty years, and when removed were found to be without rust. In another case a pipe was immersed for ten years in an artesian well, the water in which had not been pumped for 10 or 15 years, and no corrosion of this inside pipe had taken place; the scale was still as fresh as when the pipe was new, and the tool marks of the pipe-coupling apparatus were still perfectly fresh.
>
> Similar results came under the writer's observation in reference to the condition of rods and nails found in wooden foundations where the surrounding material was impervious to air, and in one case which came under his observation, at the time of the removal of the old elevated railroad columns in Greenwich street, New York City, prior to making way for the new structure in 1878, the bottom part of these columns and the bolts in the masonry were found intact, the corrosion gradually increasing until near the surface, where the material was almost entirely destroyed by rust. This experience with both wood and iron where the renewal of the oxygen in the surrounding water was prevented has been uniformly that of finding the material perfectly preserved, so that, in the writer's practice, he does not hesitate to advise the use of either material under conditions where a fresh supply of oxygen is excluded.

Another very interesting contribution was that of Messrs. Solis and Guzman, Mexican Engineers, who said:

> As mixed foundations of this nature are of very recent installation it is not possible to find history concerning them that might be useful in passing judgment upon this subject. On the other hand, general and numismatic archeology might contribute some data, especially the latter, as, for instance, in the case of Chinese iron coins, now found in museums, and which may have been for many years under water.
>
> With regard to fresh water, we have no knowledge of data that would show how iron behaves after an indefinite period of immersion. The iron of hydraulic wheels, metal gates and many other objects used in the industries permanently immersed apparently remains well preserved when subject to the continuous, or at least to the frequent flow of water. In these cases deterioration due to wear by friction of water is greater than that due to oxidation, and, as the renewal of parts happens slowly, and original shapes are always retained, the illusion of the immortality of the metal is produced, which in reality is only perpetu-

ity of form. In still waters oxidation is more rapid, but it reaches the interior of the metal very slowly, the first coating of oxidation formed, becomes a protecting coat against the propagation of this deterioration, and a condition of permanent equilibrium and preservation seems to become established. Iron buried in foundations invaded by water is subject to these conditions exactly, and as the mass of the foundation is strongly compressed, the lack of air renewal is complete, the temperature low and uniform, and the oxidating forces are paralyzed. It is probable that iron in foundations, under these conditions, if it is not indefinitely preserved, at least its deterioration must take place very slowly; and as this deterioration consists in the chemical change of one body into another, the result, under the constant powerful action of the weight of the building, can only cause, in its turn, a very gradual settlement of the foundation, until, by necessity, a final settlement is reached. This will be the result even though the mass of iron is finally changed to a mass of oxide of iron, since it is probable that, on account of the constant pressure to which it is subjected, hollows could not be left on the mass.

In conclusion it may be stated that, while there seems to be no positive evidence available to prove that iron or steel embedded in the ground will last indefinitely, there is sufficient assurance that this material will be preserved long enough to meet all the requirements of ordinary construction. As stated by Messrs. Solis & Guzman in their communication above referred to: "The spirit of the present epoch is not as conservative as that of the past, and does not occupy itself with the indefinite conversation of things, because we know better than those before could have known, that the exigencies of progress, in its continuous necessity for new adaptations, demand less durability in modern processes."

LETTERS TO THE EDITORS.

Should the Location of Long Grade Lines Always Be Begun at the Top?

Sirs:—In your issue of April 21, there appears an article that deals with the location of railroads and gives rules whereby a wooden man without the bump of location could possibly locate.

There is one of these rules that I would like to criticise and in order to give my authority for the criticism will indulge in a little autobiography. In 1884 I was made locating engineer on a piece of road in Ohio that was as crooked as a dog's hind leg. My previous experience was a four months' trip as transitman twelve years before. I had to get there and I did. Since then I have made something like one thousand miles of location in all sorts of country from the level plains of Kansas to the hills of Southern Indiana, where a three-tenths grade lies on top of the hills with deep hollows between. I think from the experience I have had that I am qualified to write about what we might term Mr. Kyle's rule Number 107 which is: "Always begin long grade lines at the summit." I have heard of this before and I claim it to be wrong. There are three factors to long grade lines. The two fills at the bottom and the cut or tunnel at the top and the proper thing to do is to run a close preliminary over the hill to the bottom on the far side and probably a mile or two farther, then go back and locate and fit the country as closely as possible. By doing this you can keep your station numbers continuous and avoid a break. Yours truly,

W. B. EELLS.

Mount Gilead, Ohio, May 5, 1909.

Catalogs Worth Having.

Engineers and contractors should have on file the latest catalogs of machines, tools and supplies that they use. In sending for catalogs reviewed or advertised in this paper, you will confer a favor on us if you will write direct to the advertisers and state that you saw the catalog mentioned in ENGINEERING-CONTRACTING. If you are in the market for tools, machinery or supplies, tell us and we will notify promptly the leading manufacturers.

No. 1227. **Concrete Block Machines.**—The DeArmon-McKinney Mfg. Co., Piqua, O.

This pamphlet describes the block machine made by the above named company and outlines the advantages claimed for it. This machine manufactures blocks by the pressure process.

No. 1228. **Shovels.**—Conneaut Shovel Co., Conneaut, O.

This 9-page pamphlet illustrates and describes the line of shovels, spades and scoops made by the above named company. An introduction relates in an interesting manner the development of the Mikkola patent or Rinberg shovels and explains their special features.

No. 1229. **Coal and Ore Handling Machinery.**—C. W. Hunt Co., 45 Broadway, New York, N. Y.

This catalog of 86 pages describes the various forms of coal and ore handling machines and plants sold by this well known concern.

No. 1230. **Steel Centers for Large Sewers.**—Blaw Collapsible Steel Centering Co., Pittsburg, Pa.

Illustrates and describes briefly the construction of Blaw centers used in several large sewers, one of 25 ft. arch span.

No. 1231. **Air Compressors.**—Thos. H. Dallett Co., Philadelphia, Pa.

This 24-page pamphlet describes in some detail the construction of the Dallett air compressor. Each part of the machine is separately illustrated and there are also a number of tables showing sizes, capacities, etc., of the various compressors made by the company.

No. 1232. **Cement Sidewalk Construction.**—Vulcanite Portland Cement Co., Land Title Bldg., Philadelphia, Pa.

This little pamphlet, written by Albert Moyer, is a short treatise on materials and methods to be employed in the construction of cement sidewalks. There are 29 pages of text and a number of useful tables. Altogether the pamphlet contains a large amount of valuable information and should be secured by contractors having sidewalk work to do

No. 1233. **Browning Excavating Machinery.**—Browning Engineering Co., Cleveland, O.

In a series of five handsomely printed pamphlets the above named company describes briefly and illustrates by means of halftones and line drawings a number of its more important excavating machines. The machines described are locomotive cranes, railway ditchers, scrapers, bucket excavators, steam shovels and automatic buckets.

No. 1234. **Centrifugal Pumps.**—Alberger Pump Co., New York, N. Y.

This is a very good descriptive catalog of the volute centrifugal pump made by the above named company. There are 40 pages of text and illustrations. The pamphlet discusses the development and theory of centrifugal pumps and then describes the design and construction of volute centrifugal pumps in detail. There is in addition a large amount of information regarding the use of this type of pump for various kinds of service.

No. 1235. **Coal and Ore Handling Machinery.**—C. W. Hunt Co., West New Brighton, N. Y.

The reputation of this company for its line of coal and ore handling machinery is so well known that the character of the machines described in this pamphlet needs no detailed explanation. The pamphlet, which has 86 pages of text and illustrations, covers about every kind of machine and device made by the company for handling ore and coal. The pamphlet is accompanied by a very useful little metric conversion table.

No. 1236. **Pelton Water Wheels.**—The Pelton Water Wheel Co., New York, N. Y.

This is a 116-page pamphlet notable for the excellent manner in which it has been prepared as well as for its contents. Pelton Water Wheels are described in great detail and numerous tables are given of their capacity, dimensions, etc. In addition there are tables on loss of head in pipe by friction, on weir measurement, on flow in flumes and ditches, on riveted hydraulic pipe, etc. The feature which will interest many engineers is a standard set of specifications covering one complete unit of a Pelton wheel power plant.

No. 1237. **Quick Unloading Car Chute.**—Southern Foundry Co., Owensboro, Ky.

This pamphlet illustrates and describes a chute which is intended to be attached to the sides of cars which contain coal, crushed stone, gravel or similar material. The chute is filled by shoveling from the car and then the contents are dumped into a wagon, a full wagon load at a time. This device has been very successfully used and will interest contractors who have material to unload from cars into wagons.

No. 1238. **Road Plows.**—The Vulcan Plow Co., Evansville, Ind.

The plow described in this pamphlet is notable for its light weight, accompanied by great strength. The strength is gained by a special method of trussing the plow beam. Contractors will be interested in the claims made by the manufacturers.

No. 1239. **Mixing and Placing Concrete.**—United Kansas Portland Cement Co., Suite 811, Commerce Bldg., Kansas City, Mo.

This pamphlet is a reprint of a paper by Messrs. Wilson and Gaylord on "How to Mix Concrete," which was published by the American Association of Portland Cement Manufacturers. The paper describes an economical method of mixing concrete by hand, going into every detail of the work and giving many useful tables.

No. 1240. **How to Construct and Preserve Macadam Roads and Prevent Dust.**—Barrett Mfg. Co., New York, N. Y.

This pamphlet contains some of the most attractive views of improved roads which we have ever seen. The text describes the development and character of the special road oil known as Tarvia. The various qualities of this oil are described and the method of applying it is explained. Testimonials are given from a number of municipalities which have used Tarvia in improving their macadam roads and there is also a large amount of general information regarding oiled road construction.

No. 1241. **Engineers Instruments and Drafting Materials.**—Technical Supply Co., 46 E. 14th St., Union Square, New York, N. Y.

This 300-page catalog gives a complete line of engineers' and surveyors' instruments and of tools, materials and appliances used in drawing-offices.

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The Foundations of Reinforced Concrete Arches.

The safety of an arch is the solidity of its foundations. This statement is not altogether true but it is of such general truth that we may let it pass. Designers of stone arches seldom fail in appreciating the vital importance to such arches of their foundations. We do not say that stone arches have not failed because of insecure foundations, there have been numbers of such failures, but usually because of faulty construction individually or of misjudgment and seldom because of failure to appreciate their supreme importance. Is this true also of concrete and reinforced concrete arch work? We have sometimes thought that it was not. At any rate the matter is not unworthy of thought.

The stone arch never occupied the position that the concrete arch has come to occupy. It was never built in competition with steel or wood. After the advent of the steel bridge it was never built at all except when a monumental structure was wanted or when the maximum in solidity and durability could be afforded. To the last class belongs the stone arch bridge work done by the Pennsylvania R. R. in years past and to the first class belong the Cabin John Arch, the famous High Bridge at New York City and numerous other street and park bridges here and in Europe. The building of a stone arch under these conditions was the result of deliberate thought. It was not undertaken unless the conditions voiced a demand for its superior beauty and permanence so compelling that the matter of its greater cost than steel could be excused. When undertaken it was with a feeling of heavy responsibility for the action and with the knowledge that success alone would justify that action. Under such circumstances care was natural and assured. Nothing took precedence of structural stability and soundness. Engineers failed in skill and judgment at times, but seldom did this failure result from indifference or recklessness.

With the advent of the reinforced concrete arch, conditions changed. The new material was, compared with stone arch masonry, cheap—so cheap that it presented the possibility of direct competition with steel as a bridge material. Engineers saw this and laudably sought to take advantage of it. Out of the fact there grew up also engineering contracting specialists in reinforced concrete work. To them, in some instances at least, the commercial value of the new material was its principal appeal. With them the question came to be not whether a reinforced concrete arch bridge could be built safely and so close in cost to a steel bridge that its superior solidity and durability and perhaps beauty would carry the decision in its favor, but whether it might not be built so cheaply that it would win over steel in direct cost competition. This is a fact and it has had its influence on reinforced concrete bridge construction and this influence has, we believe, not been, or at least, has not always been, to the interests of the best engineering work.

In making this criticism of the engineering-contracting specialist in reinforced concrete we must not be misunderstood. The development of reinforced concrete construction to the prominence it occupies today owes a large debt to these men and firms. This is as true of Europe as it is of America. But we cannot wink away the fact that they have taken chances—the chances that a salesman takes and will take in competition when an order is depending and not merely the chances that an engineer who has only the best engineering result in mind will permit himself to take. Sometimes, too, we feel that the engineer has not been any too conservative in risking his work, and that one of the places in which this is true is in reinforced concrete arch foundation work.

This is the point that we have to make. Not a particularly sharp or forcible one perhaps but one that it is well worth while to keep in mind. Reinforced concrete arch foundations are not generally faulty. There are scores of arches of this kind doing their work all over the land to stamp any other conclusion with folly. But are risks not being taken in reinforced concrete arch foundation work more often than good engineering warrants? We all know of some cases where risks have been taken. We hear occasionally of reinforced concrete arch foundation failures and whenever in such cases we study the details we must all confess that no such foundation would ever have been risked had the arches been of stone. Doubtless there is some warrant for this, the reinforced concrete arch is capable of standing abuse under which a stone arch would fail, but this warrant is not too great and we should keep this fact in mind.

Cleansing by Fire.

The University of Illinois is just now trying to get from the legislature of its home state an enlarged appropriation for one of its departments. There is nothing strange in this fact. Nearly every state university in nearly every state makes the same attempt nearly every time the state legislature meets. At Illinois this year, however, the conventionality of common procedure has been upset by one of the trustees, a lady, who objects to the appropriation as an extravagance. This act has caused no little excitement. Names have even been called in a dignified manner, of course. Naturally that doughty exponent of higher education, Mr. R. T. Crane, [illegible] of Illinois, has been unable to keep off the firing line. In an open letter to the university trustees he expresses the view that the lady who has taken [illegible] for a college-bred [illegible] in resisting an appropriation of money. He upholds her charge that the appropriation is an extravagance. Indeed, his criticism [illegible] of little [illegible] college training that [illegible] forgets his [illegible] and takes precedence of his

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companion in the attack by several vigorous bounds. "Better," he says, "put a torch to the whole outfit" than to waste more good money. To use the language of the uncollegiate, this is "going some," even for Mr. Crane.

Mr. Crane is well known to our readers as a highly successful manufacturer of supplies and appliances used in engineering construction. He has built up an industry in which he is wholly justified in taking pride. Incidentally he has become wealthy. He has done all this without, we believe, a college education. Of late years he has sought recreation and surcease from business cares by combatting the somewhat common belief in the advantages of university training. His writings comprise many articles and at least one book. We have read the book and some of the articles—most engineers doubtless have. A few engineers have even written replies to them. Mr. Crane's latest writing, noted above, is much the same as all his other writings except, we think, his suggestion that our various universities be burned down, is new. He finds that college education is unnecessary to success in commercial or industrial pursuits; that it is quite as useless in engineering work. This is not all. A college training is in his opinion not only negatively valueless, it is positively objectionable. Our boys, he says, come away from college priggishly contemptuous of men who work with their hands and too lazy or too vain of their scholarship to work themselves. He would have the boys now sent to college kept at home and taught to work and help support their parents. He would have the money now spent in supporting colleges, distributed among the common schools to provide manual training, etc. He would have a great many other things which we do not recall distinctly, but all of which would result in banishing the university and the university professor.

Our call to combat Mr. Crane's ideas is not strongly felt and we shall suppress even the slight impulse to do so that we have. We can hardly approve, however, of any suggestion to burn our universities. This seems like waste. We do not now know just to what really useful purpose they could be put, but someone whose inventiveness is unhampered by college training should, we feel, be able to devise a substitute for the scourge of fire. Were they more centrally located they might be converted into branch factories for Mr. Crane and other captains of industry. Perhaps they could be made into "homes" for indigent college graduates. These of course are mere suggestions. We really do not think much of them ourselves, but offer them as the best that occur to us at the moment. Do not, we urgently demand, burn our universities until all other possible means of finding future use for them have been conservatively canvassed by Mr. Crane.

Concrete and Reinforced Concrete Section

Note:—This section is devoted to methods and cost of constructing concrete and reinforced concrete structures. It will cover the selection, testing and proportioning of concrete materials; laboratory tests of concrete; concrete mixing, transportation and placing; fabrication and placing of reinforcement, and form construction and erection. It will also contain articles on new and interesting developments in the design of reinforced concrete.

Representative Railway Practice in the Design of Plain and Reinforced Concrete Retaining Walls with a Discussion of the Effect of Earth Pressure.*

The committee has collected information bearing on the practice of railroad companies in retaining-wall design. Diagrams giving dimensions of a number of representative retaining walls are included together with some description and comment. The practice of using arbitrary ratios of width of base to height of walls is general. These ratios are very variable and generally no attemp is made to calculate the earth pressure back of the wall in order to determine the direction and position of the resultant pressure on the foundation. The term, "width of base," is used by some to designate the extreme width of the lowest footing of the wall and by others the "neat work" above the footing, a difference in usage which has been the cause of much confusion.

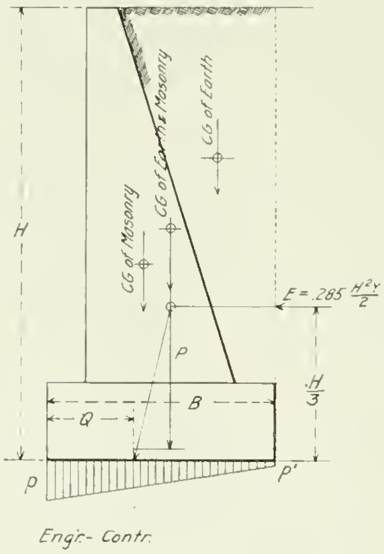

Fig. 1.

The use of a fixed ratio of width to height, which seems to be common practice, leads to a neglect of the study of the distribution of the pressure on the foundation. This is a question of great importance, since it is well established that movements from the original alinement, due to unequal settlement, form a defect more common than any other. The introduction of reinforced concrete retaining walls adds another reason for requiring an analysis of the forces and pressures. The committee therefore feels that attention should be called to the importance of making a study of each case, and particularly of the amount and distribution of the pressure on the bed or foundation.

Notwithstanding the importance of an analytical treatment, the committee deems it proper to add a word of caution on the acceptance of existing formulas, with the constants usually quoted, without further investigation. There is a feeling in some quarters that the direction and amount of

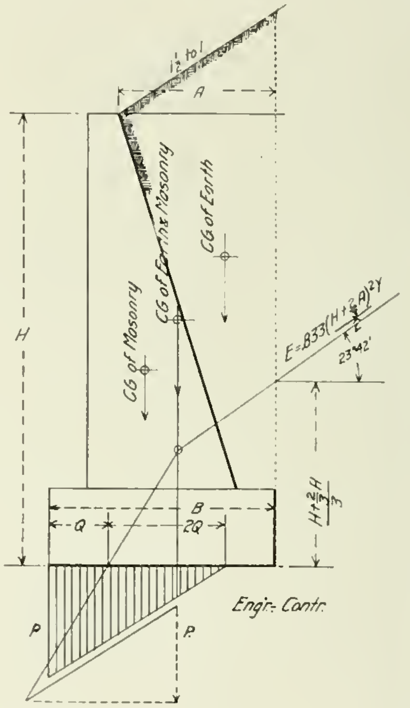

Fig. 2.

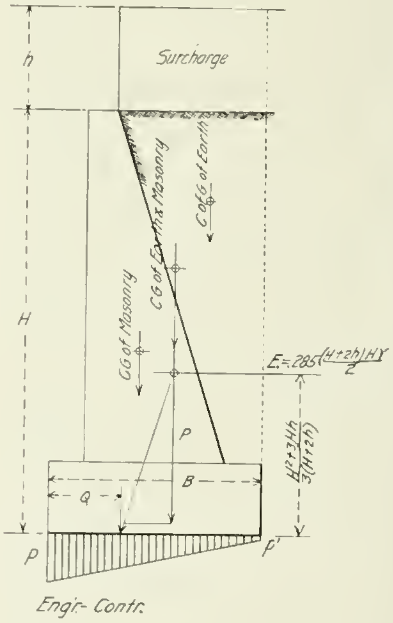

Fig. 3.

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*Extract from the report of the Committee on Masonry to the American Railway Engineering and Maintenance of Way Association.

the resultant pressure and the distribution of the pressure over the bed are not well represented by some of these formulas. If these doubts have a actual basis some of the present tendencies in retaining wall designs are open to criticism. The committee hopes to present a fuller discussion in a later report and possibly to obtain information on the pressures developed.

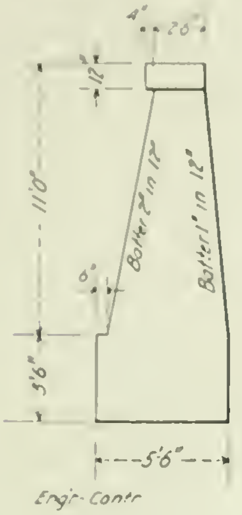


Fig. 4 (R = 0.38).

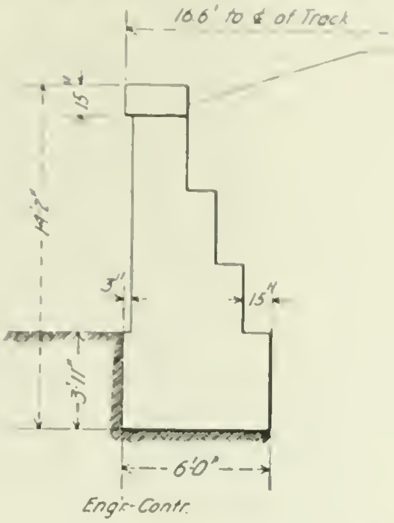


Fig. 5 (R = 0.43).

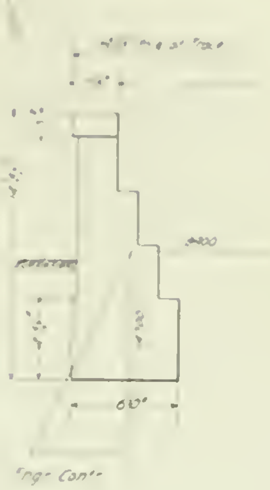


Fig. 6 (R = 0.4).

Meanwhile the committee submits the following method, which is widely published and frequently used for determining the pressures on the back and on the foundation of retaining walls. It is based on the well known Rankine formulas, which consider that the earth is a granular mass with some assumed or determined angle of repose. In applying this method it is immaterial whether the force representing the earth pressure is considered as acting directly on the back of the wall or if it is considered as acting upon a vertical plane passing through the extreme back of the footing. In the latter case the force representing the lateral earth pressure must be combined with (1) the vertical force representing the weight of the earth prism between the back of the wall and the vertical plane considered, and (2) combined with the vertical force representing the weight of the wall itself.

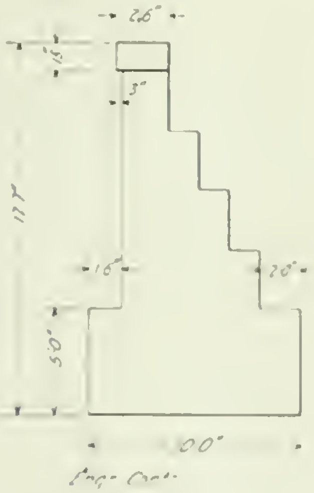


Fig. 7 (R = 0.57).

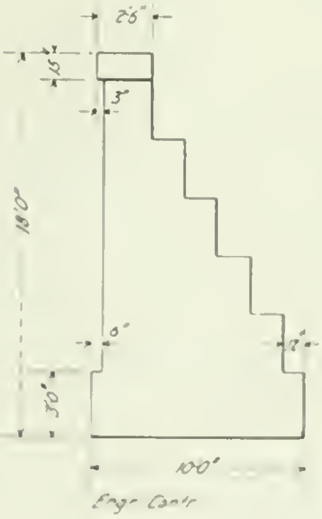


Fig. 8 (R = 0.55).

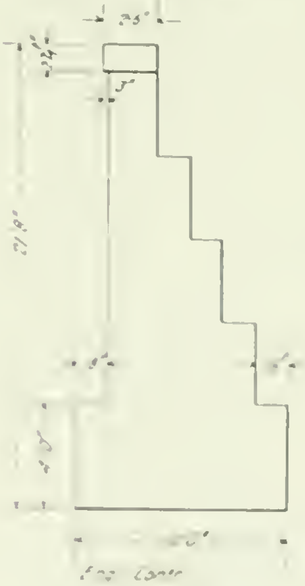


Fig. 9 (R = 0.46).

If the angle of repose of the earth is assumed as 1½ to 1, the force per linear foot of wall representing the resultant of the earth pressure back of the wall acting on the vertical plane referred to, will be as shown on the diagram Fig. 1 for the case of the top of the fill level with the top of the wall; and diagram Fig. 2 for the case of the fill sloping up from the top of the wall at an angle of 1½ to 1 indefinitely. In all cases γ = the weight of a cubic foot of earth, H being taken in feet.

If in addition to the weight of earth, the wall is to support a track load, then the earth pressure by this same method will be that indicated by the diagram Fig. 3.

In all cases the pressue on the foundation by this method will be determined by the following formulas.

When Q is equal to or greater than $\frac{B}{3}$

$$\text{Pressure at the toe} = (4B - 6Q)\frac{P}{B^2}$$

$$\text{Pressure at the heel} = (6Q - 2B)\frac{P}{B^2}$$

When Q is less than $\frac{B}{3}$

$$\text{Pressure at the toe} = \frac{2P}{3Q}$$

Where P = the vertical component of the resultant pressure on the base.

B = the full width of the base in feet.

Q = the distance from the toe to where the force P cuts the base.

The above method seems to be as rational as any that the committee can present at this time. The constants given apply only to earth that will stand on a 1½ to 1 slope, and it must be borne in mind that the pressure on the foundation should never exceed the safe bearing pressure on the material considered.

Means should always be provided for draining the earth back of a wall, otherwise the wall will be subjected to hydrostatic pressure which will greatly increase the lateral thrust.

The foundation for a wall should always be placed below frost. Usually a wall designed to resist overturning will be secure

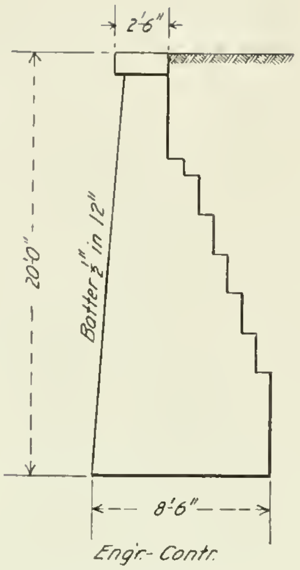


Fig. 10 (R = 0.43).

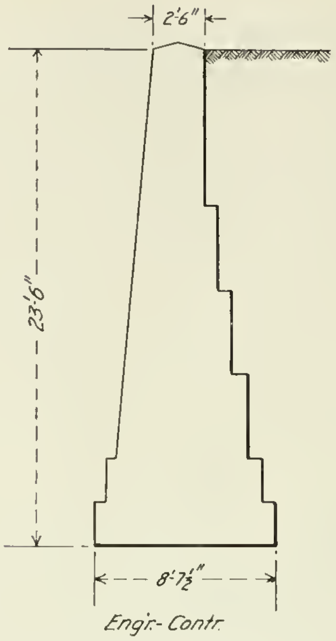


Fig. 11 (R = 0.37).

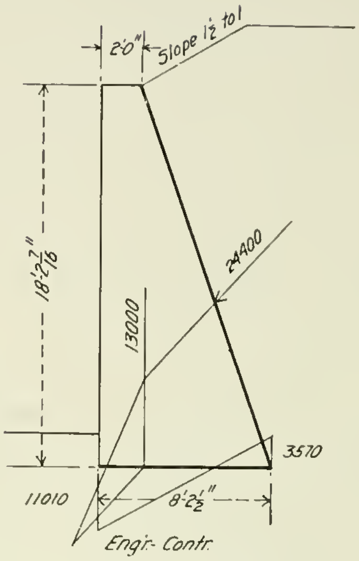


Fig. 12 (R = 0.45).

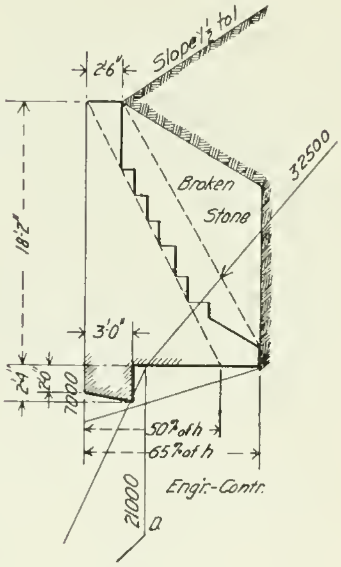


Fig. 13 (R = 0.65).

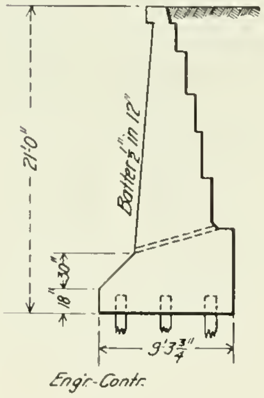


Fig. 14 (R = 0.44).

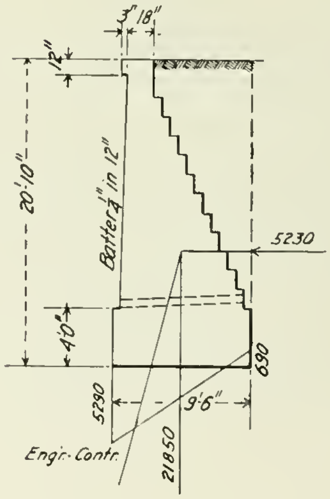


Fig. 15 (R = 0.46).

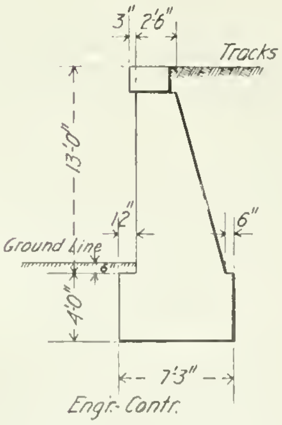


Fig. 16 (R = 0.43).

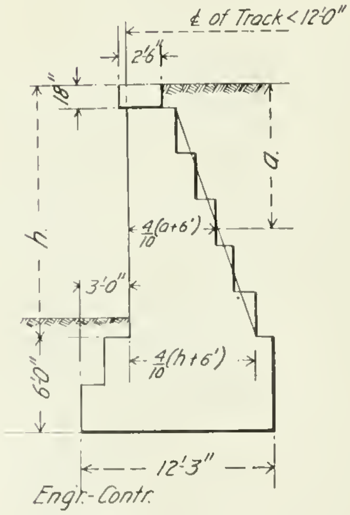


Fig. 17 (R = 0.625).

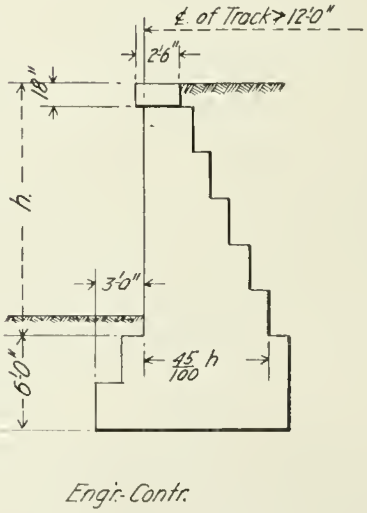


Fig. 18 (R = 0.5).

against sliding on its foundation, but this feature should receive careful attention. The frictional resistance on the base, combined with the abutting resistance of the earth in front of the wall, must be greater than the horizontal thrust of the earth back of the wall, in order to prevent sliding of the wall on its foundation.

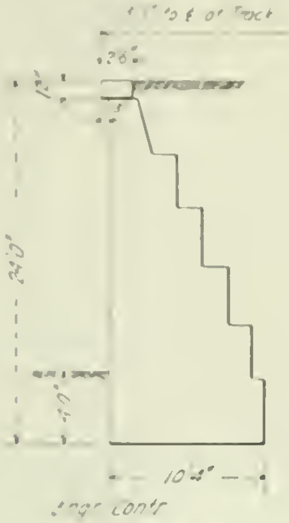


Fig. 19 (R = 0.43).

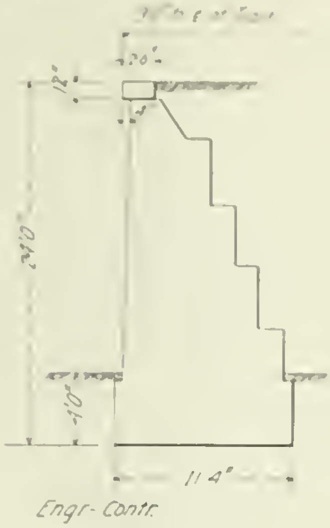


Fig. 20 (R = 0.47).

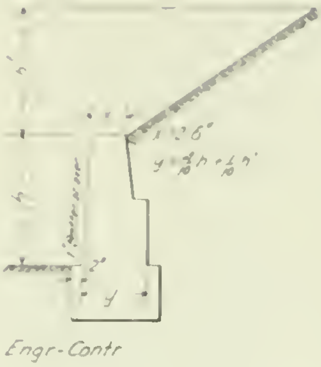


Fig. 21.

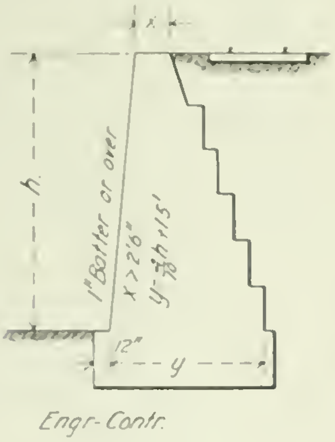


Fig. 22.

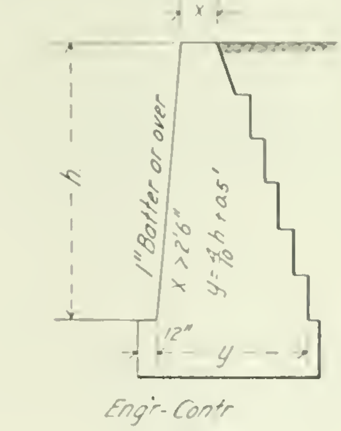


Fig. 23.

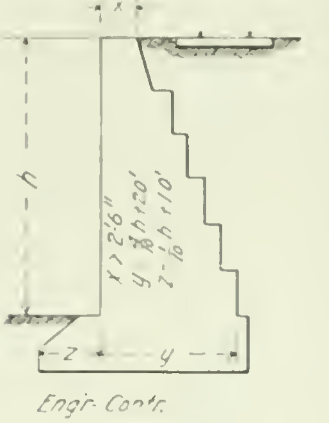


Fig. 24.

A brief review of some of the wall sections reported to your committee follows. Cross-sections of these walls are shown, all drawn to the same scale. The ratio of the base to height (*R*) is given under each figure.

Figure 4 illustrates a type of wall having considerable batter on the face and a nearly vertical back. Applying the earth pressure *E* on the back of this wall (as given in Fig. 1 for earth level with the top of the wall), the resultant will fall inside of the middle third of the base. If, however, the wall supports tracks and a surcharge load equal to 10 ft. of earth is considered (as given in Fig. 3), the resultant will pass almost exactly through the toe of the wall.

Figures 5 to 9, inclusive, are cross-sections of walls retaining track elevation embankments. Several of these walls have given considerable trouble by moving out at the top. The sections, Figs. 7 and 8 are reported as not having moved out. Fig. 9 has moved out 2½ ins., Fig. 5, 4 ins., and Fig. 6, 11 ins. In all of these cases the toe pressures as determined by the methods outlined are very great.

Figures 10 and 11 represent two old walls both of which have tipped forward several inches, the latter as much as 15 ins.

Figure 12 is a wall that fell over and was replaced by the wall shown in Fig. 13. The earth pressures and resultants through the bases are drawn in on the figures. Figure 13 has not moved. These walls have rock foundations.

Figures 14 and 15 are parallel walls not carrying tracks. Figure 15 is a rubble masonry wall built twelve or more years ago. It has moved out at the top as much as five inches. Figure 14 is of concrete, built two years ago, and rests upon piles. It has shown no movement. The piling takes care of the heavy pressure under the toe of the wall.

Figure 16 is another track elevation wall that has moved out at the top 7½ ins. The company that built this wall has adopted the designs shown in Figs. 17 and 18. The very generous projection of the footing in front of these walls greatly increases their resistance to displacement, although the toe pressures still may be large.

Figures 19 and 20 are parallel walls. The former is evidently less stable than the latter. However, the tracks are much closer to the latter and it is reported to have moved out 4 ins. at the top. It is surprising that Figure 19 has not moved out; evidently it is on a very solid foundation.

Figures 21 to 24, inclusive, indicate the method adopted by one railroad in designing retaining walls for track elevation. It is not reported whether or not these walls moved out, nor are any heights given.

Figure 25 is a cross-section of a retaining wall built by the Chicago & Northwestern Railway for track elevation work in Chicago. This wall is unique in that the face consists of a series of recessed panels between pilasters. Expansion joints are provided about 50 ft. apart. The wall is supported on a pile foundation.

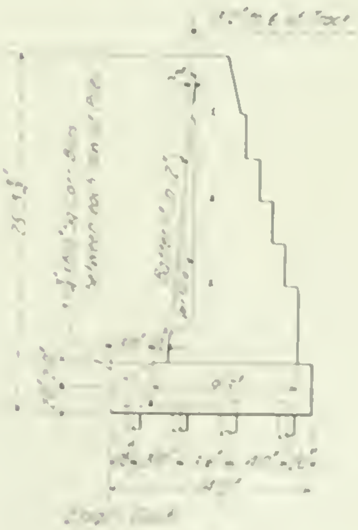


Fig. 25 (R = 0.55).

Figures 26 to 37 are illustrations of reinforced concrete cantilever walls, all of which have been built within the last two or three years. Most of these walls have much greater resistance to overturning and much lower earth pressures on their bases than the plain masonry walls illustrated. They are designed as cantilever beams, with steel bars, to take the tensile stresses. The simpler the shape of these walls, the less expensive the form work. This feature has been especially considered in Figure 28. Generally there will be found considerable economy in this type of wall over plain monolithic walls.

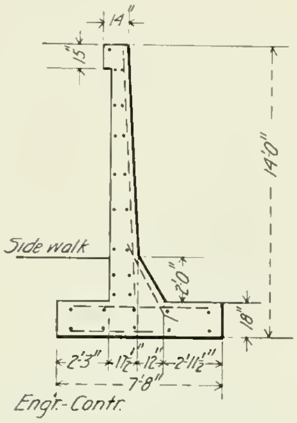


Fig. 26 (R = 0.55).

Figure 26 is a wall built at Milwaukee by the Chicago, Milwaukee & St. Paul Ry., Mr. C. F. Loweth, Engineer and Superintendent Bridges and Buildings. It is 1,000 ft. long and has a maximum height of 14 ft. above foundation.

Figures 27 and 28 were designed by the Condron & Sinks Co., Consulting Engineers. The former, for Marion county, Indiana, is about 800 ft. long and was built in 1904. The latter was designed for the Union Railway Co. of Memphis, Tenn., Mr. John Lancaster President and General Manager. It is 500 ft. long and was built in 1907. The cost, including excavation, was $7,527, or $6,118, exclusive of excavation. The cost per cubic yard of concrete in place, including reinforcing, was $8.82.

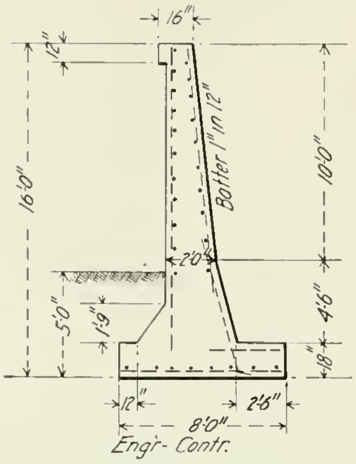


Fig. 27 (R = 0.5).

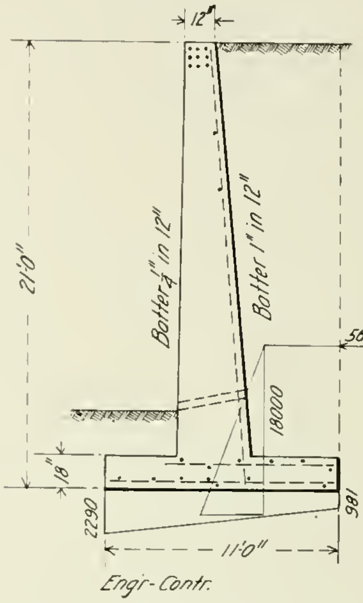


Fig. 28 (R = 0.56).

Figures 30 and 31 are walls of the Chicago track elevation of the Chicago, Burlington & Quincy Railroad, Mr. C. H. Cartlidge, Bridge Engineer. These walls are a compromise between plain monolithic and cantilever types of walls. Figure 30 is the general type built by this road, while Figure 32 represents an unusually high wall, built directly on the property line, where there was no chance to extend the footing in front of the wall. These walls are supported on piles closely spaced under the toe and more widely apart under the heel. Mr. Cartlidge writes regarding these walls:

> This wall (reinforced concrete) will show an economy over a gravity wall of solid concrete. The cost of a large amount of work, including everything, has been a little less than $9 per yard. For the concrete only, exclusive of excavation and piling, $6.23 per yard. Our abutments are solid concrete, without any reinforcing. These cost us per cubic yard $5.55, including everything. The high cost per yard of the retaining walls for excavation and piling is, of course, due to the fact that comparatively little concrete is used per yard of excavation. The true comparison, therefore, is between the concrete in the two, being for the retaining walls, as stated above, $6.23 and $5.03.

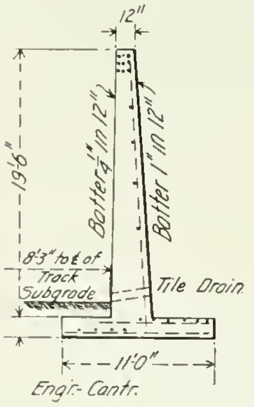


Fig. 29.

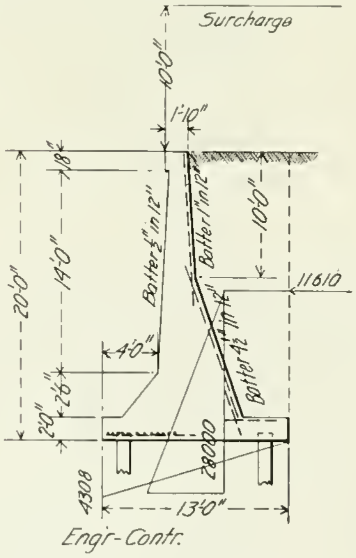


Fig. 30 (R = 0.65).

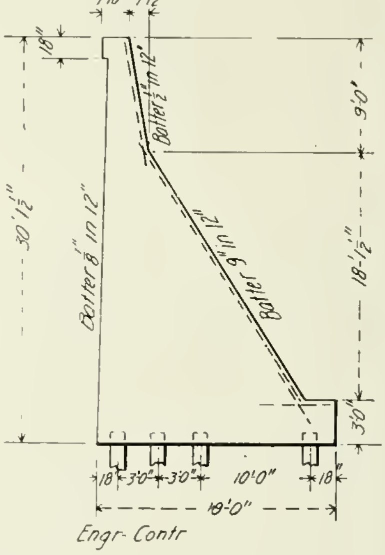


Fig. 31 (R = 0.59).

Figure 32 was built by the Louisville & Nashville R. R., and is 331½ ft. long. Figure 33 was built by the New York, Ontario & Western Ry. as a wing wall for an abutment. Its height varies from 26 to 35 ft. and contains 528 cu. yds. of concrete.

Figures 34 to 37, inclusive, illustrate buttressed, or, more correctly, counterforted walls and abutments. This is, thin curtain walls braced at intervals by buttresses or counterforts, and supported on a broad foundation platform on which the weight of the embankment rests. Hence, here as also in the cantilever type of wall, the weight of the embankment itself gives stability to the wall against overturning. In this type of wall, because of the fact that it is but little heavier per cubic foot than the bank it is to retain, particular attention must be given to prevent the wall from sliding forward on its foundation. Figure

It is a typical section of a wall built by the Great Northern Ry.

Figure 34 is a typical section of a wall built by the Canadian Pacific Ry. at Montreal. This wall is 1,400 ft. long and varies in height from 21 to 25 ft.

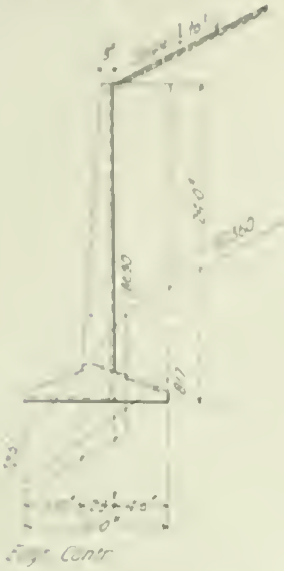


Fig. 32 (R = 0.47).

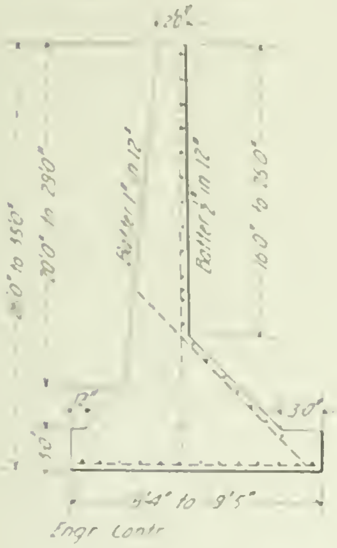


Fig. 33 (R = 0.59).

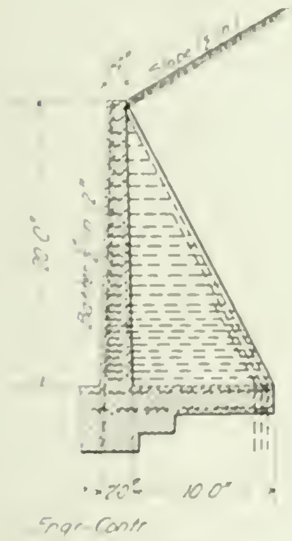


Fig. 34 (R = 0.6).

Mr. J. G. Sullivan, Assistant Chief Engineer, states regarding [illegible] walls:

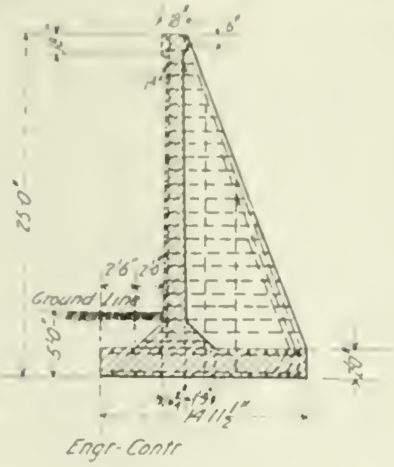


Fig. 35 (R = 0.6).

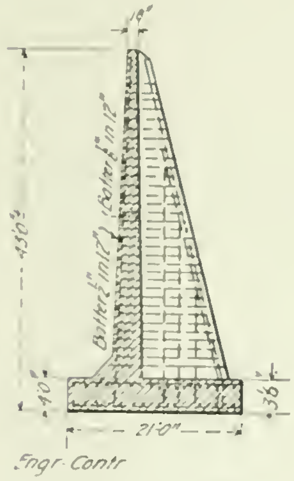


Fig. 36 (R = 0.49).

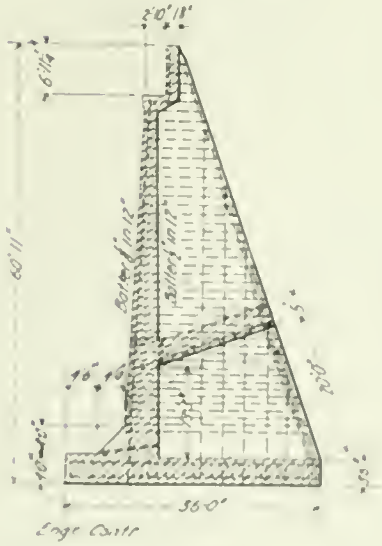


Fig. 37.

With regard to cost, we have found that for walls up to [illegible] ft. high from bottom of foundation slab, the reinforced concrete is about 20 per cent cheaper than a [illegible] concrete.

Figures 36 and 37 are sections of an [illegible] abutment 61 ft. high built by the Atlanta, Birmingham & Atlantic R. R. Mr. Alex Bonnyman, General Manager and Chief Engineer, who writes regarding their walls and abutments:

By the contract prices for plain concrete and reinforced concrete in abutments and retaining walls, we figure that there is a saving in the reinforced walls of about [illegible] per cent.

According to Jefferson Middleton of the U. S. Geological Survey, the total cost of the buildings erected in the principal cities of the United States in 1908 was $540,467,[illegible]. In 1907 the cost of buildings in these same cities reached a total of $620,1[illegible]. The decrease in cost in 1908 therefore amounts to $79,681,[illegible], or 12.71 per cent. The following table shows the number of permits issued and the cost of buildings erected in each of the cities.

	No. of permits or buildings.	Cost of buildings.
Allegheny, Pa.	(*)	(*)
Atlanta, Ga.	[illegible]	$ 4,[illegible]941
Baltimore, Md.	2,8[illegible]	[illegible]
Boston, Mass.	[illegible]	11,[illegible]712
Brooklyn, N. Y.	10,76[illegible]	47,[illegible]249
Buffalo, N. Y.	2,788	6,847,000
Cambridge, Mass.	427	2,122,074
Chicago, Ill.	10,027	67,2[illegible]
Cincinnati, Ohio	[illegible]	6,428,888
Cleveland, Ohio	6,674	9,[illegible]869
Columbus, Ohio	1,[illegible]	[illegible]27[illegible]
Dayton, Ohio	1,191	[illegible]
Denver, Colo.	3,117	10,098,[illegible]
Detroit, Mich.	3,662	10,682,170
Fall River, Mass.	299	1,140,9[illegible]
Grand Rapids, Mich.	1,064	2,181,77[illegible]
Hartford, Conn.	676	3,177,[illegible]48
Indianapolis, Ind.	4,013	[illegible]
Jersey City, N. J.	1,[illegible]	4,140,466
Kansas City, Kan.	792	1,1[illegible]472
Kansas City, Mo.	3,840	10,762,041
Los Angeles, Cal.	7,371	[illegible]931,377
Louisville, Ky.	[illegible]	2,914,141
Lowell, Mass.	497	1,[illegible]
Memphis, Tenn.	2,519	3,[illegible]
Milwaukee, Wis.	4,169	10,06[illegible]669
Minneapolis, Minn.	[illegible]638	1[illegible]915
Nashville, Tenn.	4,217	[illegible]
Newark, N. J.	2,419	7,161,6[illegible]
New Haven, Conn.	914	[illegible]
New Orleans, La.	2,42[illegible]	[illegible]744,[illegible]
New York, N. Y.	6,103	117,819,182
Omaha, Neb.	1,726	4,[illegible]
Philadelphia, Pa.	[illegible]	[illegible]
Pittsburg, Pa.	*4,023	*1[illegible]
Providence, R. I.	1,[illegible]86	[illegible]
Reading, Pa.	571	497,700
Richmond, Va.	1,3[illegible]	[illegible]
Rochester, N. Y.	1,[illegible]	[illegible]
St. Joseph, Mo.	675	1,717,[illegible]
St. Louis, Mo.	9,119	[illegible]
St. Paul, Minn.		[illegible]
San Francisco, Cal.	[illegible]	[illegible]
Scranton, Pa.	[illegible]	[illegible]
Seattle, Wash.	7,901	[illegible]
Syracuse, N. Y.	1,[illegible]41	[illegible]
Toledo, Ohio	1,067	2,081,448
Washington, D. C.	[illegible]	10,[illegible]
Worcester, Mass.	1,10[illegible]	[illegible]
Total	[illegible]	$540,467,[illegible]

*Allegheny included in Pittsburg, Pa.

The Third Annual Cement Show will be held in the Coliseum in Chicago on February 17 to 23, 1910. These dates were selected after very careful consideration and in accordance with the expressed wishes of a very large majority of the exhibitors at the two previous exhibitions. The show this year proved conclusively that the latter part of February is the most satisfactory time for holding a cement show. The exhibitors at Chicago this year were all highly pleased with the date and nearly all expressed their preference in favor of holding the next show on a corresponding date. Elaborate arrangements are already under way to make the next exhibition even better than the last and it is stated that no money or effort will be spared in perfecting the arrangements. At a recent meeting of the executive committee of the Illinois Society of Municipal Contractors it was decided to hold their next annual convention in the city of Chicago during Cement Show week. This step was taken with the idea in view of permitting the members of the association who will attend the convention to also visit the Cement Show.

Earth and Rock Section

Note: This Section is devoted to methods and costs of excavating earth and rock and building embankments. It will cover the grading of roads and railroads, diking and canal work, dredging, building reservoirs and earth dams, sewer and water pipe trenching, quarrying, etc.

Methods of Making Large Blasts for Loosening Rock for Use in Rock Fill Dams With Some Results Obtained.

The following brief accounts of heavy blasts are reprinted from "Mining Science":

In the Otay Creek dam, near San Diego, Cal., the first blast made was by driving a tunnel 50 ft. into the face of the cliff in lateral drifts 18 ft. and 20 ft. long, respectively. In the shorter drift 4,000 lbs. of Judson powder containing 5 per cent nitroglycerine, under a vertical depth of 70 ft., and in the larger 8,000 lbs., under a depth of 85 ft., were exploded simultaneously, which resulted in loosening and throwing out about 50,000 to 75,000 cu. yds. of material. The second large blast was perpared by sinking a shaft 115 ft. deep, 85 ft. back from the nearly vertical face left by the first blast. At a depth of 50 ft. two drifts were run laterally a distance of 25 ft. and at the bottom of the shaft two more drifts 30 ft. and 35 ft. long, respectively, were extended into the rock towards the face and in the opposite direction, and the four holes thus prepared were loaded with 30,000 lbs. of powder, of which the greater part was located in the bottom drifts. This blast gave greater execution than the first and supplied sufficient rock to complete the dam. The quarry being near the lower toe of the dam, the first large blast filled in the toe with large boulders, some upwards of 50 tons in weight, and a subsequent freshet pouring over and through these rocks scoured out the sand beneath them so to settle them well to bedrock.

At the Morena rock-fill dam of the Southern California Mountain Water Co., 50 miles from San Diego, large blasts were employed in loosening the rock and dropping it in place in the dam. Boulders weighing hundreds of tons were thus deposited in the bed of the cañon and on its slopes. The first blast of 100,000 lbs. of powder exploded Dec. 26, 1896, moved 75,000 cu. yds. A second, fired five days later with 80,000 lbs., did good execution, and on March 24, 1897, the explosion of 70,000 lbs. loosened 100,000 tons of rock.

In building the Gatun dam on the Panama canal 25 holes were made, 19½ tons of dynamite used and 70,769 cu. yds. of rock displaced.

THE PORT OF PORTLAND

LEVERMAN'S LOG

*Date*____________________

*Dredge*____________________ *Location*____________________

*Shift No. 1*______________ *No. 2*______________ *No. 3*______________

Time	Gage	Bells	Depth	Width	Depth	Time and Cause Each Delay	Other Vessels Passed

Fig. 1.

Cost Keeping Blanks for Dredging.

From time to time this journal has received letters from engineers and contractors engaged in dredging, asking for forms to keep account of dredging work and also the cost of it. Some record blanks of this character were published in ENGINEERING-CONTRACTING for February, 1906, and in this issue we give some additional blanks.

The Port of Portland, Ore., has two hydraulic dredges at work deepening and widening the channel of the Columbia and Lower Williamette rivers. One of these dredges has a capacity of 8,000 cu. yds. per day in sand, and the other has a daily capacity of 20,000 cu. yds.

The dredges work under the direction of the chief engineer of the Port, Mr. J. B. C. Lockwood, M. Am. Soc. C. E., and he uses the following forms in keeping a record of the work done and in obtaining the costs.

In Fig. 1 is shown the blank for the leverman's report. On this report the measurements are given from which the yardage dredged can be calculated. Also a record is kept of passing vessels and all delays to the dredge.

In Fig. 2, is shown the report of the chief engineer of the dredge. From this report the delays are taken so that it can be a check on the leverman's report. As to causes for delay, the leverman shows the reason for all causes other than those occurring in the engine room, the causes for the latter delays being given on the engineer's report. This report also shows the amount of fuel used. The dredges for this work burn sawdust and shavings, the quantity being measured and estimated in cubic feet.

In Fig. 3 is shown the blank used for the captain's report. The other reports are meant to show some details for each shift, there being 3 shifts of 8 hours each, while in this report all the work is grouped for the 24 hours. This report is evidently made from the two previous blanks and also from data collected by the captain, or under his direction.

In Fig. 4 is shown the cost analysis sheet, gotten up each month by the chief engineer of the Port. This form is at once a summary and also an analysis showing the cost per day, the cost per cubic yard, the average time worked per day, with average work done. This report is made up from the daily reports of the captain and also from the timekeepers' sheets or pay rolls. We regret we cannot reproduce a copy of these forms. In all cases there should be blank forms, showing the number of men worked on each shift, their positions and rates of wages.

Special attention is also called to the analysis sheet, as this is a weak point in many cost-keeping systems; that is, the lack of an analysis sheet. From such a sheet it is possible, at any time, to learn of the efficiency of the work being done, and at the end of any job the average cost is quickly calculated. This is not possible when daily sheets only are kept without a great deal of labor, and when a large number of daily reports have accumulated it frequently happens that it is never done. Thus the greatest value of cost keeping, namely, showing the efficiency of the work done, is not obtained.

List of Permissible Explosives Tested Prior to May 15, 1909.*

As a part of the investigation of mine explosions authorized by Congress in May, 1908, it was decided by the Secretary of the Interior that a careful examination should be made of the various explosives used in mining operations, with a view to determining the extent to which the use of such explosives might be responsible for the occurrence of these disasters.

The preliminary investigation showed the necessity of submitting to rigid tests all explosives intended for use in mines where either gas or dry inflammable dust is present in quantity or under conditions which are indicative of danger.

With this in view, a letter was sent by the Director of the United States Geological Survey on January 9, 1909, to the manufacturers of explosives in the United States, setting forth the conditions under which these explosives would be examined and the nature of the tests to which they would be subjected.

Inasmuch as the conditions and tests described in this letter were subsequently followed in testing the explosives given in the list below, they are here reproduced as follows:

(1) The manufacturer is to furnish 100 lbs. of each explosive which he desires to have tested; he is to be responsible for the care, handling and delivery of this material at the testing station on the United States arsenal grounds, Fortieth and Butler streets, Pittsburg, Pa., at the time the explosive is to be tested, and he is to have a representative present during the tests who will be responsible for the handling of the packages containing the explosives until they are opened for testing.

(2) No one is to be present at or to participate in these tests except the necessary government officers at the testing station, their assistants, and the representative of the manufacturer of the explosive to be tested.

(3) The tests will be made in the order of the receipt of the applications for them, provided the necessary quantity of the explosive is delivered at the plant by the time assigned, of which due notice will be given by the Geological Survey.

(4) Preference will be given to the testing of explosives that are now being manufactured and that are in that sense already on the market. No test will be made of any new explosive which is not now being manufactured and marketed until all explosives now on the market that may be offered for testing have been tested.

(5) A list of the explosives which pass certain requirements satisfactorily will be furnished to the state mine inspectors and will be made public in such further manner as may be considered desirable.

TESTING REQUIREMENTS FOR EXPLOSIVES.

The tests will be made by the engineers of the United States Explosives Testing Station at Pittsburg, Pa., in gallery No. 1. The charge of explosive to be used in tests 1, 2 and 3 shall be equal in disruptive power to one-half pound (227 grams) of 40 per cent nitroglycerin dynamite in its original wrapper of the following formula:

Nitroglycerin	40
Nitrate of sodium	44
Wood pulp	15
Calcium carbonate	1
	100

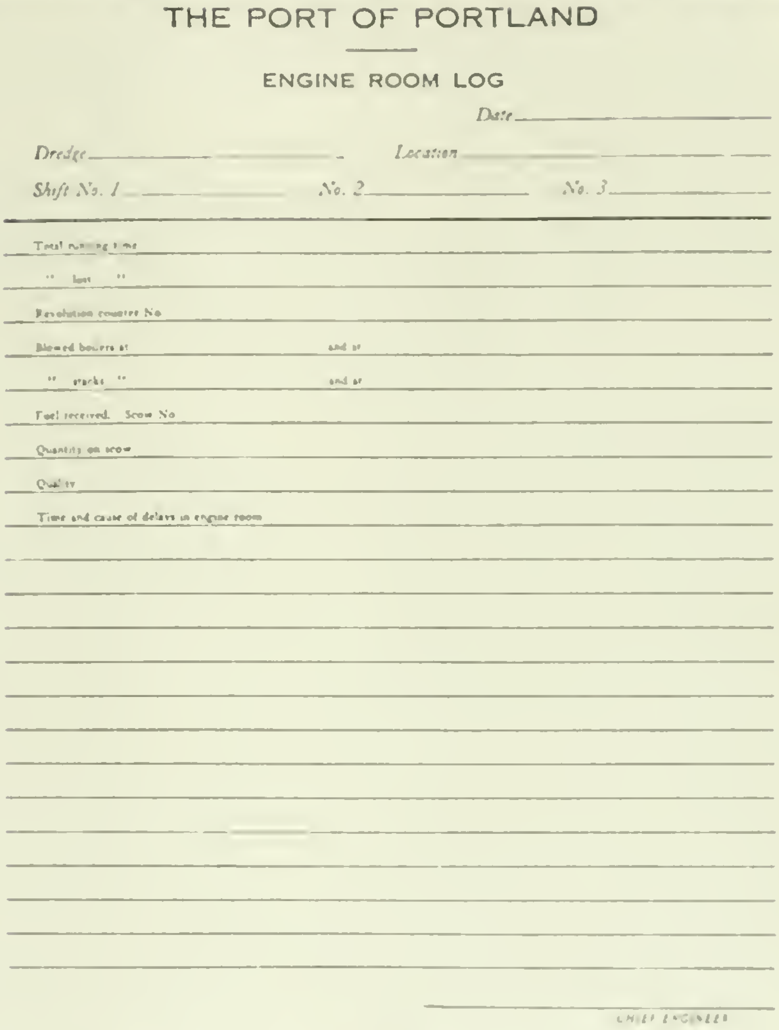
Each charge shall be fired with an electric fuse of sufficient power to completely detonate or explode the charge as recommended by the manufacturer. The explosive must be in such condition that the chemical and physical tests do not show any unfavorable results. The explosives in which the charge used is less than 100 grams (0.22 pound) will be weighed in tinfoil without the original wrapper.

The dust used in tests 2, 3 and 4 will be of the same degree of fineness and taken from one mine.

Test 1.—Ten shots with the charge as described above, in its original wrapper, shall be fired, each with 1 pound of clay tamping, at a gallery temperature of 77° F., into a mixture of gas and air containing 8 per cent of methane and ethane.* An explosive will pass this test if all ten shots fail to ignite the mixture.

Test 2.—Ten shots with charge as previously stated, in its original wrapper, shall be fired, each with 1 lb. of clay tamping at a gallery temperature of 77° F. into a mixture of gas and air containing 4 per cent of methane and ethane and 20 lbs. of bituminous coal dust, 18 lbs. of which is to be placed on shelves laterally arranged along the first 20 ft. of the gallery and 2 lbs. to be placed near the inlet of the testing station in such a manner that all or part of it will be suspended in the first division of the gallery. An explosive will pass this test if all ten shots fail to ignite the mixture.

Test 3.—Ten shots with charge, one pre-



THE PORT OF PORTLAND

ENGINE ROOM LOG

Date __________

Dredge __________ *Location* __________

Shift No. 1 __________ *No. 2* __________ *No. 3* __________

Total running time __________

" lost " __________

Revolution counter No. __________

Blowed boilers at __________ and at __________

" stacks " __________ and at __________

Fuel received. Scow No. __________

Quantity on scow __________

Quality __________

Time and cause of delays in engine room __________

____
CHIEF ENGINEER

Fig. 2.

PERMISSIBLE EXPLOSIVES TESTED PRIOR TO MAY 15, 1909.

Brand	Manufacturer
Aetna coal powder A	Aetna Powder Co., Chicago, Ill.
Aetna coal powder B	Aetna Powder Co., Chicago, Ill.
Carbonite No. 1	E. I. Du Pont de Nemours Powder Co., Wilmington, Del.
Carbonite No. 2	E. I. Du Pont de Nemours Powder Co., Wilmington, Del.
Carbonite No. 3	E. I. Du Pont de Nemours Powder Co., Wilmington, Del.
Carbonite No. 1 L. F.	E. I. Du Pont de Nemours Powder Co., Wilmington, Del.
Carbonite No. 2 L. F.	E. I. Du Pont de Nemours Powder Co., Wilmington, Del.
Coal special No. 1	Keystone Powder Co., Emporium, Pa.
Coal special No. 2	Keystone Powder Co., Emporium, Pa.
Coalite No. 1	Potts Powder Co., New York City
Coalite No. 2 D	Potts Powder Co., New York City
[illegible] dynamite No. [illegible]	[illegible] Powder Co., Emporium, Pa.
[illegible] dynamite No. [illegible]	[illegible] Powder Co., Emporium, Pa.
[illegible] dynamite No. [illegible]	[illegible] Powder Co., Emporium, Pa.
Masurite M. L. F.	Masurite Explosive Co., Sharon, Pa.
Meteor dynamite	E. I. Du Pont de Nemours Powder Co., Wilmington, Del.
Monobel [illegible]	E. I. Du Pont de Nemours Powder Co., Wilmington, Del.

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*Explosives Circular No. 1, Department of the Interior, United States Geological Survey.

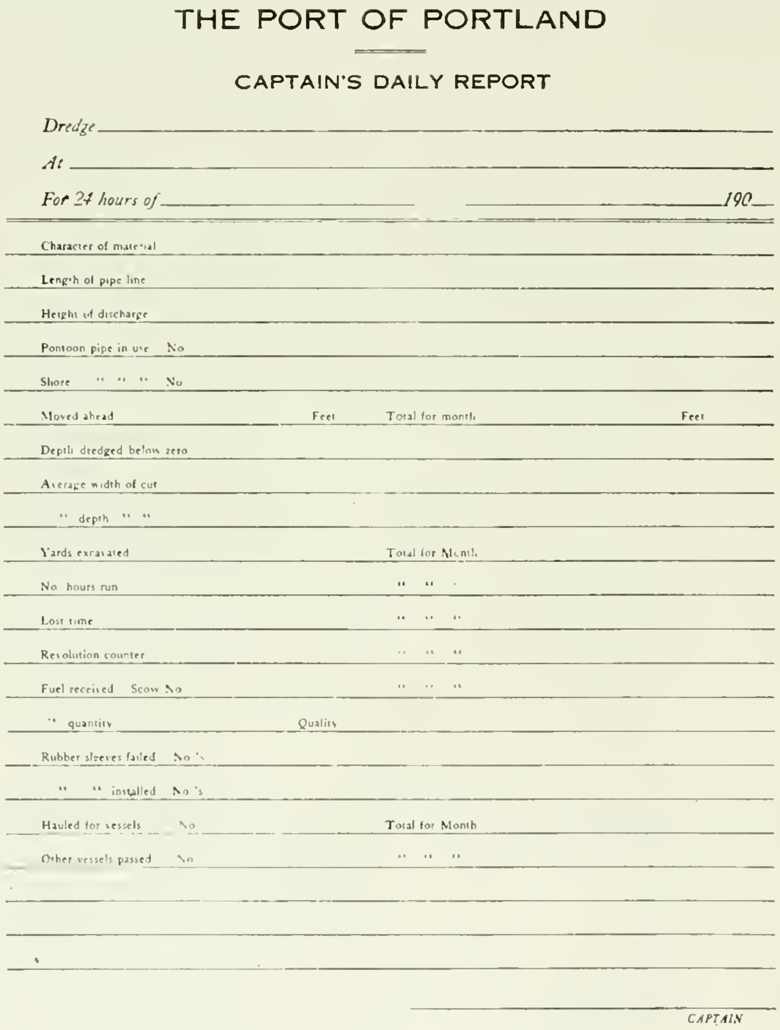
*With a view to obtaining a [illegible] of uniform purity and [illegible] uniformity.

viously noted, in its original wrapper, shall be fired, each with 1 lb. of clay tamping at a gallery temperature of 77° F., into 40 lbs. of bituminous coal dust, 20 lbs. of which is to be distributed uniformly on a horse placed in front of the cannon and 20 lbs. placed on side shelves in sections 4, 5 and 6. An explosive will pass this test if all ten shots fail to ignite the mixture.

Test 4.—A limit charge will be determined within 25 grams by firing charges in their original wrappers, untamped, at a gallery temperature of 77° F., into a mixture of gas and air containing 4 per cent of methane and ethane and 20 lbs. of bituminous coal dust, to be arranged in the same manner as in test 2. This limit charge is to be repeated five times under the same conditions before being established.

Note.—At least 2 lbs. of clay tamping will be used with slow-burning explosives.

In response to the above communication applications were received from 12 manufacturers for the testing of 29 explosives. Of these explosives the 17 given in the following list have passed all the test requirements set forth, and will be termed permissible explosives.



THE PORT OF PORTLAND

CAPTAIN'S DAILY REPORT

Dredge ______

At ______

For 24 hours of ______ ______ *190*__

Character of material ______

Length of pipe line ______

Height of discharge ______

Pontoon pipe in use No ______

Shore " " " No ______

Moved ahead ______ Feet Total for month ______ Feet

Depth dredged below zero ______

Average width of cut ______

" depth " " ______

Yards excavated ______ Total for Month ______

No hours run ______ " " ______

Lost time ______ " " " ______

Revolution counter ______ " " " ______

Fuel received Scow No ______ " " " ______

" quantity ______ Quality ______

Rubber sleeves failed No 's ______

" " installed No 's ______

Hauled for vessels No ______ Total for Month ______

Other vessels passed No ______ " " " ______

______ CAPTAIN

Fig. 3.

Subject to the conditions named below, a permissible explosive is defined as an explosive which has passed gas and dust gallery tests Nos. 1, 2 and 3 as described above, and of which in test No. 4 1½ lbs. (680 grams) of the explosive has been fired into the mixture there described without causing an ignition.

Provided:

1. That the explosive is in all respects similar to the sample submitted by the manufacturer for test.

2. That double-strength detonators are used of not less strength than 1 gram charge consisting by weights of 90 parts of mercury fulminate and 10 parts of potassium chlorate (or its equivalent), except for the explosive "Masurite M. L. F.," for which the detonator shall be of not less strength than 1½ grams charge.

3. That the explosive, if in a frozen condition, shall be thoroughly thawed in a safe and suitable manner before use.

4. That the amount used in practice does not exceed 1½ lbs. (680 grams) properly tamped.

Cost of Driving Piles by Horse Power.

The work consisted in driving piles by horse-drive. The hammer weighed 2,000 lbs., and was raised by block and tackle by horses, two teams being used alternately. As soon as the hammer was tripped, two men hauled back the hammer rope and hooked it onto the second team while the first was returning.

The contract price was 25 cts. per foot, delivered and driven, and a gang averaged about 360 lin. ft. of pile driven per 10-hour day, using a gang of a foreman, five laborers and two teams. The cost was:—

Five laborers at $1.75	$ 8.75
One foreman	3.50
Two teams (and driver) at $5	10.00
Rent of pile driver	3.00
Total	$25.25

Therefore, 360 lin. ft. cost $25.25, or 7.01 cts. per lin. ft.

In driving piles for a roundhouse two drivers were employed. For the first, a team of horses was used to lift the hammer, which was tripped by hand. A gang of four men, one team and a foreman averaged twelve 25-ft. piles per day. The piles were in groups of six, each group being 20 ft. apart, so that some time was consumed in moving the driver. The distribution was as follows:

One team	$5.00
One man tripping	2.00
Two men guiding pile	3.50
One man pointing pile	1.75
Two laborers at $1.75	3.50
One foreman	3.50
Total	$19.25

That is, 300 ft. cost $19.25, or 6.4 cts. per lin. ft. for driving.

On another piece of the same work one horse with a capstan was used for raising the hammer, which weighed 1,800 lbs. Here the driving was for the walls, the piles being 2 ft. on centres, so that little time was wasted in moving the driver. In this case the cost was as follows:

One single team	$3.50
Four laborers at $1.75	7.00
One foreman	3.50
Total	$14.00

They averaged seven 25-ft. piles per day: that is, 175 feet at $15, or 8 cts. per lin. ft. for driving.

We are indebted to the "Canadian Engineer" for this information.

A commission has been appointed by Governor Fort of New Jersey to make a valuation of the railway and canal property of that state. The resolution adopted by the state legislature first recites that no "new and complete inventory of railroad and canal property" has been made since 1886, and that it is desirable to have such an inventory for the "use of the people of the state, the legislature, the state board of assessors and the state board for the equalization of taxes." Accordingly, the governor is authorized, subject to the approval of the senate, to appoint three persons, at least two of whom shall be experts, to value all the railroad and canal property in the state, and submit an inventory of the same. Franchises are to be valued separately. The work will be done under the general direction of the governor and on lines laid down by him. The work is to be completed and the report submitted to the governor by Sept. 1, 1909, and the report must be made public and be submitted to the Legislature of 1910. The compensation of the commissioners, aside from reasonable expenses, is to be fixed by the governor. The commission consists of Messrs. Samuel Whinery, M. Am. Soc. C. E., who resides at East Orange; Charles Hansel, M. Am. Soc. C. E., of Cranford, and Frank Stevens, of Jersey City.

A street car track in which the rails are fastened by clips to steel I-beam cross-ties, 3 in. high and 6 ft. long, spaced about 6 ft. or 8 ft. apart, is described in the report of T. S. Oxholm, Principal Assistant Engineer, Richmond Borough, New York. These cross ties are set to grade and a concrete beam built, 15 in. wide and 9 in. deep, below each rail enclosing the end of the tie. No other concrete is used beneath the tie. The pavement foundation joins the concrete beam and surrounds the rail. Tie rods are used around curves and at other places where they seem necessary. This form of construction is stated to have resulted in an excellent road-bed

A concrete slope paving is being placed on about 1½ miles of dyke along the banks of the Ohio River at Cincinnati, to protect the dyke from wash at the flood stages of the river. In the past disastrous washouts have occurred almost annually, doing much damage to valuable farm land, tying up an important thoroughfare along the top of the dyke, and at times being accompanied by loss of life. The improved dyke will extend completely across a section of low land known as Turkey Bottoms, and will safeguard the adjacent lands against repetition of the floods. The entire cost of the work will be about $125,000. A protective paving of concrete about 6 ins. thick is being laid over the entire river face of the dyke. Small round reinforcing bars are placed in the concrete at 2 ft. intervals, both along and up the slope. In placing the concrete the slope is divided into strips 6 ft. wide, and vertical boards set in place on the division lines. Alternate strips are concreted while the intervening spaces are left for the laborers to work in. The concrete is mixed on a platform at the top of the slope and is shoveled directly on the inclined face, where the laborers, standing on cleated boards laid between the concreted strips, rake it down over the face and tamp it in place. Finishers follow the concreting gang to level off and smooth the surface. The work is carried on in this way on one day, placing the concrete only in every other 6 ft. strip. On the following day the boards are removed and the intervening strips concreted.

Roads and Streets Section

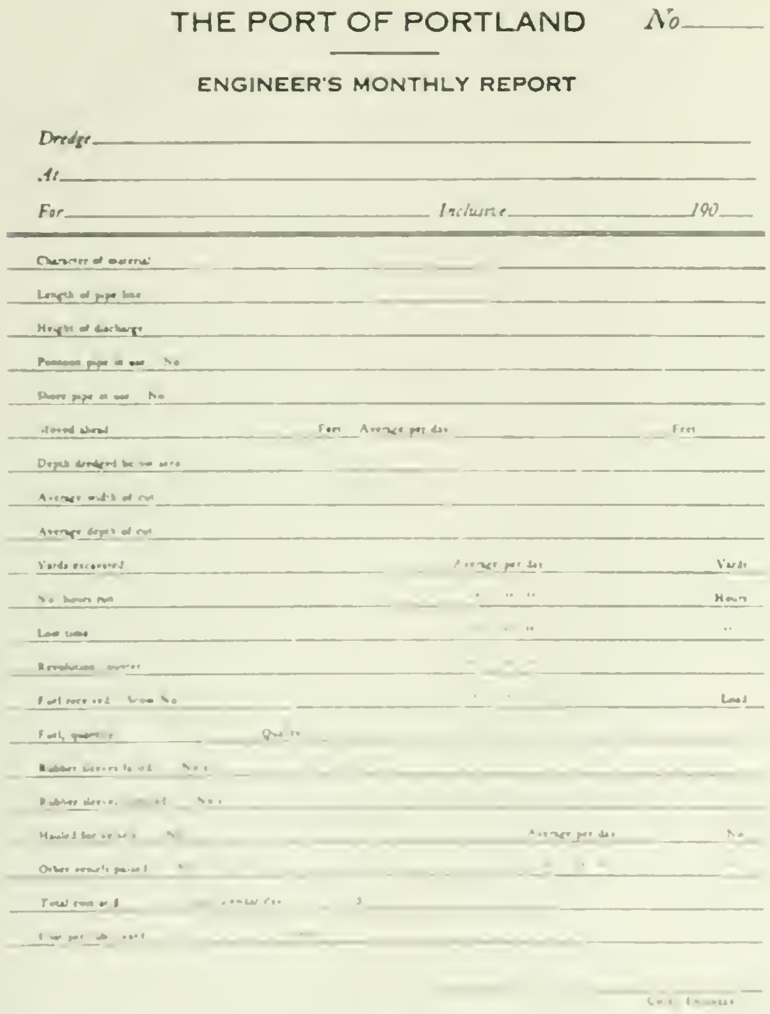
Note: This Section is devoted to methods and costs of road and street construction. It will cover road building in all its details, the construction of pavements, sidewalks and gutters, the testing and use of paving materials and the machinery and tools used in road building and paving.

The Theory of Economic Road and Street Design and Location.

VII

Cost of Ascent and Descent.—While as we have seen, the greatest cost of hauling over a hill arises from the fact that it limits the size of the loads, there is a further item of cost to consider in overcoming ascents, namely the cost of the energy required to overcome the resistance of gravity. In railway location the cost of each foot of rise and fall is quite a considerable item, due to the increased coal consumption. In road location there is a cost of overcoming ascents that is analogous, for the motive power—the horse—has a limited capacity for work.

A 1,200 lb. horse is capable of doing about 16,000,000 ft.-lbs. of work daily, as we have seen, in addition to the work of lifting its own body each step that it takes. A team of horses pulling a light 1,600 lb. wagon loaded with 6,000 lbs. has the following work to perform in overcoming each foot of vertical ascent or rise:



THE PORT OF PORTLAND No.______

ENGINEER'S MONTHLY REPORT

*Dredge*______

*At*______

*For*______ *Inclusive*______190__

Character of material______

Length of pipe line______

Height of discharge______

Pontoon pipe in use No.______

Shore pipe in use No.______

Moved ahead______Feet Average per day______Feet

Depth dredged below zero______

Average width of cut______

Average depth of cut______

Yards excavated______Average per day______Yards

No. hours run______" " "______Hours

Lost time______" " "______"

Revolutions, cutter______

Fuel received from No.______Load

Fuel, quantity______Quality______

Rubber sleeves used No.______

Rubber sleeves, on hand No.______

Hauled for______No.______Average per day______No.

Other vessels passed______

Total cost of______ [illegible]______

Cost per cubic yard______

______

Chief Engineer

Fig. 4.

	Ft.-lbs.
Weight of 2 horses	2,400
Weight of wagon	1,600
Weight of load	6,000
Total	10,000

Since the two horses are capable of doing 2 × 16,000,000 = 32,000,000 ft.-lbs. of work daily, it is evident that each 1 ft. of ascent consumes 0.03 per cent of their available energy. This energy costs, say, $3.00 per team a day (including wages of driver), hence 0.03 per cent of $3.00 = $0.0009, which is the cost of overcoming 1 ft. ascent.

If there is a hill 100 ft. high, up which 1,000 loads (of 3 tons each) must be hauled annually, then the cost of making the ascent is $0.0009 × 100 × 1,000 = $90. Capitalizing we have $90 ÷ 4% = $2,250, which is the sum that may be profitably spent to avoid making this ascent.

The cost of each *ascent* going toward the market should be estimated in this manner. Each *descent*, on the other hand, must be credited with the horse work that is saved. The horse itself can avail itself in descending, of none of the work expended in raising its own weight in ascending, for it is not like a wagon on wheels, hence there is no credit for the 2,400 ft. lbs. of work for each foot of descent, due to the weight of the team of two horses. On the other hand, on all grades less steep than the slope of repose, there is full credit for the work of the wagon and its load, or 7,600 ft. lbs. per ft. of descent. But, on all grades steeper than the slope of repose, either brakes must be applied or the horses must hold the load back, in either case causing a waste of the energy of the descending load. On a paved road having a tractive resistance of 40 lbs. per ton the slope of repose is a 2 per cent grade, hence on grades steeper than 2 per cent calculate the number of feet of descent for the horizontal distance traveled exactly as if they were 2 per cent and to this add the total actual feet of vertical descent on all grades of less than 2 per cent, the grand total will be the number of feet of descent to be credited as reducing the horse work.

To illustrate, suppose there is a descent on a 5 per cent grade for 1,000 ft., followed by a descent of 2,000 ft. on a 1½ per cent grade. The horse work saved on the 1,000 ft. is 2 per cent (not 5 per cent) of 1,000 = 20 ft. of descent (the other 30 ft. being consumed by friction of brakes or otherwise), and the horse work saved on the 2,000 ft. is 1½ per cent of 2,000 = 30 ft.; this makes a total of 50 ft. of credited descent (although the actual descent is 80 ft.). If the wagon and its load are 7,600 lbs., as above given, the value of 1 ft. of descent is 76 per cent of the value of 1 ft. of ascent (the ascending load being 10,000 lbs., including the horses), or 0.76 × $0.0009 = $0.00068. Hence the credit due to the 50 ft. of descent, on the basis of 1,000 loads per annum, is 50 × $0.00068 × 1,000 = $34, which capitalized at 4 per cent is $34 ÷ 4% = $850. This amount is deducted from the capitalized cost of the ascent, which, in the above example, was $2,250, thus leaving $1,400 as the net cost of climbing the hill, which is the amount that may be profitably expended to eliminate this rise and fall entirely.

This method of calculation of the value of rise and fall involves a distinct departure from that given in any text book on roads, for the reason that authors of road books have not only neglected to consider the weight of the horses but have fallen into the error of regarding a foot of "rise and fall" on roads as being exactly analogous to a foot of "rise and fall" on the railways. On a railway, however, the loads are usually carried *both* ways, whereas they are usually carried only *one* way on roads, which make it illogical to attempt to deduce any definite value for 1 ft. of "rise and fall," taken as one item together, on a road. Hence we have separated the two, and have calculated the value of 1 ft. of ascent, and of 1 ft. of descent, and have regarded them as debits and credits to be applied to each hill.

Based upon the above assumption as to weight of horses (1,200 lbs. each), load hauled (3 tons net per team), rate of wages (30 cts. per hour for two horses and driver), and rate of interest on capital (4 per cent), we have the following rule:

Debit each hill with 2¼ cts. for each foot of ascent for each load hauled over it during the year. Credit the hill with 1.7 cts. for each foot of descent for each load, estimating each grade of less than 2 per cent at its actual descent, but estimating the descent on each grade of more than 2 per cent as if it were only 2 per cent. The net debit is the justifiable expenditure to eliminate the hill.

Example. A hill 100 ft. high has an ascent of 4,000 feet long on a 2½ per cent grade, and a descent of 1,000 feet on a 5 per cent grade, followed by 2,500 ft. descent on a 2 per cent grade. What expense is justified to eliminate the hill, if it is to be macadamized, and if 4,000 loads of 3 tons are to pass over it annually?

Solution: The debit due to ascent is $2\frac{1}{4}$ cts. $\times 100 \times 4{,}000 = \$9{,}000$. The first 1,000 ft. of descent credited on a 2 per cent (not 5 per cent) basis is 20 ft.; the final descent of 2,500 ft. on the 2 per cent grade is 50 ft.; making a total credit of 70 ft. on the descent. Hence the credit due to the descent is 1.7 cts $\times 70 \times 4{,}000 = \$4{,}780$. Therefore, $\$9{,}000 - \$4{,}780 = \$4{,}220$ is the amount that may be justifiably expended to eliminate the hill entirely.

Rules similar to the above can be prepared to fit any given conditions as to wages, loads, interest on capital, etc.

A hill may be eliminated either by excavating or by making a detour around it. In the latter case, the cost of the increased distance becomes a matter for consideration, and this problem should be attacked as follows:

The value of 1 ft. of Distance—The value of a foot of increased distance is ascertained by adding three items: (1) The actual first cost of building 1 ft. of road; (2) the capitalized value of the total team time required to travel the extra foot of distance; and (3) the capitalized value of maintaining 1 ft. of road.

If a team travels 2½ miles, or 13,200 ft., an hour, and if a team (including driver) costs 30 cts. per hour, there would appear to be an added cost of 30 cts. $\div 13{,}200 = 0.0023$ ct. per loaded team per foot of added distance; but, as a matter of fact, this cost is only half the real cost per load per foot of added distance, for the wagon is loaded only when going to market and must also travel this extra foot when returning unloaded. Hence the real cost is $0.0023 \times 2 = 0.0046$ ct. per *load* per foot of added distance. If the load is 3 tons, the cost is, therefore, 0.0015 ct. per ton per foot of added distance. If there are 1,000 tons hauled per year, then we have 0.0015 ct. $\times 1{,}000 = 1.5$ ct. per ft. of distance. Capitalizing this at 4 per cent, we have $1.5 \div 4$ per cent $= 37\frac{1}{2}$ cts., which is the value of 1 ft. of distance per 1,000 tons hauled annually.

The cost of maintaining this 1 ft. of road should next be considered. We have seen that on macadam it costs 0.4 ct. per ton-mile for maintenance, hence the cost per ton-foot is a little less than 0.00008 ct.. For 1,000 ton-ft., this would be 0.08 ct.. which capitalized at 4 per cent is 2 cts. Adding this to the 37½ cts. we have a total of 39½ cts., or practically 40 cts., per ft. per 1,000 tons of annual traffic.

The first cost per foot of road varies widely, but, for illustration, assuming it to be \$1 per ft., a rule like the following should be applied by the road locating engineer:

To a first cost of \$1 per ft. of distance add 40 cts. per 1,000 tons hauled per annum over the section of road in question, to get the total value of 1 ft. of distance.

Example: The capitalized cost of ascent and descent on a hill is \$4,200 for a traffic of 12,000 tons. To go around the hill will add 800 ft. of distance. Is this added distance justifiable?

Solution: The value of 1 ft. of distance is $\$1 + 12 \times 40$ cts. $= \$5.80$; hence the value of 800 ft. is $\$5.80 \times 800 = \$4{,}640$. This indicates that it will scarcely pay to go around the hill.

(To be continued.)

Progress Reports of Experiments in Dust Prevention, Road Preservation and Road Construction, By the U. S. Office of Public Roads.

During the summer of 1908 a number of experiments in road preservation and construction were conducted by the U. S. Office of Public Roads in co-operation with various municipalities. This work included experiments with asphaltic preparations, tar preparations and residual oil, at Newton, Mass., the construction of an earth-asphalt road at Independence, Kan., the construction of tar-slag, tarred slag and tarred slag-limestone roads at Birmingham, Ala., and the construction of four experimental sand-clay roads in Kansas. A description of these experiments is given in a recently issued circular of the Office of Public Roads, and from that circular we have taken the matter in this article.

The experiments with dust preventives and road binders made in 1908 differ from those of earlier years mainly with respect to the manner of application of the various dust preventives and road preservatives. While the earlier experiments were concerned with the surface treatment of old roads, the later ones deal principally with the treatment of roads during construction or reconstruction. It is the belief of the Office that where new roads are being built or old ones are being resurfaced it is far better policy to incorporate a suitable binder with the road material at that time than at a later period to attempt to prevent deterioration by means of surface applications when the surface is worn and dusty. While the initial cost of such work will, of course, be somewhat greater, it should prove more economical in the long run where proper materials are employed in a suitable manner.

ASPHALTIC PREPARATIONS, TAR PREPARATIONS, AND RESIDUAL OIL.

These experiments were conducted at Newton, Mass., by the Office of Public Roads in co-operation with Mr. Charles W. Ross, street commissioner of Newton. All labor, apparatus, and road stone were furnished by the city of Newton. Some of the binding materials were donated by manufacturers and others were purchased by the city. Direction and supervision of the work were furnished by the Office of Public Roads.

Cabot St., running west from Center St., and connecting Newton with Newtonville, was selected for all experiments excepting No. 11. This street had been macadamized to a width of from 19 to 25 ft. about 20 years previously and was badly in need of resurfacing. The grade varied from 1.5 per cent to 6.35 per cent. This road is subjected to an ordinary mixed traffic in which automobiles predominate.

Crushed field and cobble stone was furnished for part of the work, but for the greater portion chlorite schist obtained from the city's quarry was used. The length of haul was considerable, four loads per team per day being the maximum and three loads the minimum. The laborers were for the most part skilled in road work and were furnished from the regular city force. The cost of labor per 8-hour day was as follows:

Common labor	\$1.75-\$2.25
Foreman	2.50
Single teams	3.50
Double teams	5.25
Roller	10.00
Roller operator	2.50

The cost of broken stone at crusher was figured at 93 cts. per cu. yd., sand at 69 cts., and gravel at 7 cts. Account was taken of all miscellaneous expenses, such as lumber for stone gauges, wood for heating purposes, drayage, interest on capital invested in apparatus, etc., and divided among the different experiments. Of the various binders used the asphalt preparation was figured at 13 cts. per gallon, oil and refined coal tar at 8 cts., and refined watergas tar at 7½ cts. This included freight charges. As some of these materials were furnished free of charge, their cost could only be estimated, and for purpose of comparison can, if desired, be eliminated in considering the various experiments, provided the quantity employed is taken into account. In different parts of the country their cost would vary, so that for estimation of similar work done elsewhere the cost at the given location should be substituted.

Owing to the distribution of the laborers and their employment in various kinds of work during the same day, as well as to occasional losses of time which are unavoidable in experimental work, it was impossible to determine accurately the increased cost of construction over that of ordinary macadam. As the average cost of macadam per square yard 1 in. in depth has in the past amounted to 10 cts. in the city of Newton, it would seem fair to deduct this amount from the total cost and consider the remainder as additional cost. New material was applied to a finished depth of 4 ins., so that the total cost per square yard minus 40 cts. will give a close approximation of the additional cost. The cost data of the different experiments are given in Table III.

All work was carried on during the months of August and September, the weather being cool. No bituminous material was mixed in wet weather, nor applied while the under surface was wet. With exceptions noted under the various experiments, the work in general was carried on as follows: The entire road was first spiked up and all stones over 3 in. in diameter removed by hand, soft places were filled with gravel and the road brought to a crown of one-half inch to the foot and well rolled with a 20-ton steam roller. A $2\frac{1}{2}$-in. course of crushed stone not larger than $2\frac{1}{2}$ in. in diameter was then spread on, water applied and the whole rolled until compact and solid. A foundation of this kind was constructed as a base for all of the experiments. As soon as the base was thoroughly dry a $2\frac{1}{2}$-in. course of warm bitumen-covered stone was speard uniformly over the whole surface and rolled until firm. The surface was finished according to methods described under the different experiments.

The bitumen-covered stone was prepared at the crusher in the following manner. The bitumen was heated in two 2-barrel kettles to a temperature of about 225° F., and at this heat was sufficiently fluid to be applied. It was then dipped out in a gallon measure and poured over thoroughly dried and heated crushed rock. The quantity of rock was carefully guaged and the sizes proportioned as given under the different experiments. All mixing was done on a large platform and the stone turned with long-handled shovels until perfectly covered. Two complete turnings were usually sufficient. The hot mixture was then hauled to the road and applied. The stone was heated on semicylindrical heaters, approximately 8 ft. by $3\frac{1}{2}$ in., closed at one end and fitted with smokestacks, wood being used as fuel. With a good fire, it was found that the stone became sufficiently hot to mix in a very short time, so that the operation of covering the heater with fresh stone and removing the hot stone was almost continuous. Two of these heaters were used for the large-sized stone and one for the small. In mixing, it was found advisable to first place a measured quantity of fine material on the platform and cover this with the proper amount of coarse material, after which the bitumen was applied. While being turned, each pile was carefully raked by a laborer equipped with an ordinary asphalt rake.

It was found most economical and convenient to mix batches of stone weighing approximately 1,300 lbs. and to employ sufficient labor to mix two batches at one time. By proper arrangement of labor, 1 foreman and 15 men could thus mix 37 cu. yds. of material per day.

The various binders were delivered in barrels and were exceedingly viscous liquids at ordinary temperatures. The asphalt and oil preparations could be run from the bung, but in some cases it was necessary to destroy the barrels containing the tar preparations in order to remove the contents. The results of examination of these various preparations are given in Tables 1 and 2.

TABLE I.—PROPERTIES OF ASPHALTIC PREPARATIONS AND RESIDUAL OIL.

Kind of test	Asphaltic preparation	Residual oil
Specific gravity 25° C./25° C.	1.1[illegible]	0.991
Flash point	[illegible]	[illegible]
Volatilization tests:	Per cent	Per cent
Loss at 212° F. (100° C.) after 5 hours	1.[illegible]	[illegible]
Loss at 325° F. (163° C.) after 7 hours	11.[illegible]	[illegible]
Loss at 400° F. (204° C.) after 7 hours	19.[illegible]	[illegible]
Residue	8[illegible].01	[illegible]
Distillation tests:		
Distillate to 110° C. per cent by volume	[illegible]	
Light oils 110° C. to 170° C. per cent by volume	1.[illegible]	[illegible]
Heavy oils 170° C. to 270° C. per cent by volume	26.[illegible]	
Soluble in CS₂ total bitumen	[illegible].62	[illegible]
Organic matter insoluble in CS₂	3.18	1[illegible]
Inorganic matter	.20	[illegible]
Total	100.00	100.00
Insoluble in CCl₄	8.61	[illegible]
Insoluble in 90 per cent benzol	6.[illegible]	[illegible]
Bitumen *e* insoluble in 86 naphtha	[illegible]	[illegible]

a Cracked, hard, brittle.
b Soft, semiasphaltic, pulled to thread.
c Distillate to 170°, when cold held about one-twelfth its volume of solids. Distillate 170° to 240°, when cold held a very small amount of solids. This distillate separated into two layers of oil, one apparently a petroleum and the other a tar product.
d Trace.
e Per cent total bitumen, 5.46.

TABLE II.—PROPERTIES OF REFINED TARS.

Kind of test	Coal tar	Water-gas tar
Specific gravity 25° C./25° C.	1.2[illegible]	1.16[illegible]
Distillation tests—	Pct	Pct
Distillate to 110° C., per cent by volume	0.[illegible]	[illegible]
Total light oils to 170° C., per cent by volume	1.[illegible]	6.[illegible]
Total dead oils, 170° C.-270° C., per cent by volume	2[illegible]	[illegible]
Pitch residue by difference	6[illegible]	41.8
Total	100.00	100.0
Soluble in CS₂ total bitumen	81.71	97.17
Organic matter insoluble in CS₂	18.18	
Inorganic matter	.11	2.83
Total	100.00	100.00
Insoluble in 99 per cent benzol	18.18	5.34

When cold, the light oils from the coal tar contained about one-eighth their volume precipitated naphthalene, while only a trace of naphthalene was found in the water-gas tar distillate. The dead oils from the coal tar contained about one-third their volume precipitated naphthalene and from the water gas tar about one twelfth their volume. The residue from the coal tar was brittle and nonlustrous; that from the water gas tar was brittle and lustrous.

Experiment No. 1.—Asphaltic Preparation.—Upon the base prepared as previously described a $2\frac{1}{2}$-in. loose coat of hot bitumen-covered stone was placed and rolled with the 20-ton steam roller until firm. The use of a smaller roller weighing not over 8 tons would have been preferable, but none of that size could be readily obtained. In this experiment the stone and bitumen were employed in the proportion of 900 lbs. to $1\frac{1}{2}$ to $\frac{3}{4}$ in. stone to 350 lbs. of $\frac{3}{4}$ to $\frac{1}{4}$ in. stone to 5 gallons of binder. This mixture could be rolled while still hot without sticking to the roller, and when firm averaged 2 in. in depth. A light coat of stone screenings one-half inch to dust was applied in quantity sufficient to fill the surface voids, and the whole well rolled. The finished road while quite solid was, of course, not so dense as though a more carefully proportioned mineral aggregate had been employed. Stones of this size, however, were more easily mixed by hand with a less amount of binder than would have been required had a greater proportion of fine material been employed.

The section treated was 222 ft. in length and averaged 23 ft. in width, giving a total area of 567 sq. yds. The amount of binder per square yard amounted to 0.51 gallon.

Experiment No. 2.—Asphaltic Preparation.—In the section reserved for this experiment it was intended to use a mineral aggregate containing some material finer than one-fourth inch in diameter, in order to reduce the percentage of voids. At the time, however, conditions were such that in order to keep the laborers constantly employed it was found necessary to carry on the mixing at two different places. No fine material being available at one of these points, a mixture similar to that described in Experiment No. 1 was the best that could be obtained. At the other mixing plant the same formula was employed with the exception that stone from $\frac{3}{4}$ in. to dust was substituted for that running from $\frac{3}{4}$ to $\frac{1}{4}$ in. Alternate loads of the mixture were applied to the road. Otherwise the experiment was identical to No. 1.

Three hundred and ninety feet by 23 ft. and 100 ft. by 19 ft. of road surface was constructed in this manner, giving a total of 1,226 sq. yds. The binder consumed amounted to 0.51 gallon per square yard, as in Experiment No. 1.

Experiment No. 3.—Asphaltic Preparation.—This experiment was in every way similar to Nos. 1 and 2, excepting that all of the bituminous mixture was made up in the proportion of 900 lbs. $1\frac{1}{2}$ to $\frac{3}{4}$ in. stone to 350 lbs. $\frac{3}{4}$ in. to dust to 5 gallons of bitumen. The stone running from $\frac{3}{4}$ in. to dust was used just as it came from the crusher. Shortly after consolidation a number of weak spots developed in all three of these sections and had to be patched with hot bitumen. This raised the total cost of each 0.99 ct. per square yard.

A section 479 ft. in length by 20 ft. in width was treated in this experiment giving a total of 1,061 sq. yds. The same amount of binder per square yard was consumed as in the preceeding experiments.

Experiment No. 4.—Asphaltic Preparation.—Instead of a surface application of stone screenings as in Experiment No. 3, a coating of tarred sand was applied in this trial section in a quantity sufficient to fill the surface voids and produce a surface somewhat resembling sheet asphalt. Refined coal tar was used for this purpose, and both it and the sand were heated before use. The additional cost of labor and material amounted to 5.86 cts. per square yard; but the general appearance of the street was greatly improved, and it is believed that this surface will prove to be more water resistant and of better wearing quality than that produced in Experiment No. 3.

A section 93 ft. in length and 20 ft. in width was treated in this manner. The total area covered amounted to 207 sq. yds. A mixture of 0.5 gallon of asphaltic preparation and 0.18 gallon of tar was used upon every square yard so treated.

Experiment No. 5.—Asphaltic Preparation.—This section of road was treated like No. 3, with the exception that a flush coat of the hot asphaltic preparation was applied to the bitumen-covered surface before spreading the stone chips. This was done by pouring the material from buckets, and, while hot, sweeping it into the surface with stiff long-handled brooms. Somewhat similar results could have been obtained with less bitumen by painting it upon the surface, but the other method was used in order to make sure that the voids were filled as completely as possible. An increase of 1.12 gallons per square yard thus occurred, and the cost, including that of labor and material, was raised 17.12 cts. per square yard.

A section 98 ft. in length and averaging $20\frac{1}{2}$ ft. in width was treated in this manner, the total area covered being 223 sq. yds.

Experiment No. 6.—Asphaltic Preparation.—This experiment was similar in every respect to No. 5, with the exception that a flush coat of the hot refined coal tar was applied instead of the asphaltic preparation.

A section 38 ft. in length and 21 ft. in width, giving an area of 88 sq. yds., was treated in this manner, 0.51 gallon of asphaltic preparation and 1.11 gallons of coal tar being consumed per square yard.

Experiment No. 7.—Asphaltic Preparation.—On account of the patching which was required in Experiments Nos. 1, 2 and 3, it was thought advisable to construct a section in the same manner as No. 3 with the addition of more bitumen. Six gallons was therefore substituted for 5 gallons in the formula for Experiment No. 3. The results were more satisfactory, as no patching was afterwards required. The cost per square yard was, however, raised 1.24 cts.

A section 232 ft. in length and 24 ft. in width was thus treated. The total area covered was 618 sq. yds. and 0.71 gallon of asphaltic preparation was applied per square yard.

Experiment No. 8.—Residual Oil.—This experiment was similar to No. 7, excepting that the semi-asphaltic residual oil was employed in place of the asphaltic preparation. After construction the road was not quite so firm as the surface produced with the asphaltic preparation, owing to the lubricating properties of the oil. The surface was somewhat roughened by horses' hoofs, but otherwise appeared fairly satisfactory.

The section treated was 74 ft. in length and 23 ft. in width, or an area of 189 sq. yds. The oil consumed per square yard amounted to 0.79 gallon.

Experiment No. 9.—Refined Water-Gas Tar.—In this experiment refined water-gas tar was used in the same manner and in approximately the same quantity as was described in Experiments Nos. 7 and 8 for the asphaltic preparation and oil. The resulting road was similar to that obtained from the use of the asphaltic preparation.

Ninety-three ft. of roadway 25 ft. wide, giving an area of 258 sq. yds., was treated in this manner, and 0.81 gallon of tar per square yard was consumed.

Experiment No. 10.—Refined Water-Gas Tar.—In this experiment the road was constructed as in Experiment No. 9, except that a coating of tarred sand was substituted for the top dressing of stone chips. The finished surface was similar to that described in Experiment No. 4 and resembled sheet asphalt. The same kind and quantity of sand and tar were used as in Experiment No. 4.

A section 326 ft. in length and 24 ft. in width, giving an area of 869 sq. yds, was treated in this manner. A total of 0.81 gallon of refined water-gas tar and 0.18 gallon of refined coal tar per square yard was consumed in this experiment.

Experiment No. 11.—Molasses-Oil-Lime.—For this experiment a section of Summit street running north from Bellevue St., and varying from 4.3 to an 8 per cent grade was selected. While subject to less traffic than Cabot St., it was badly in need of resurfacing and the same general method of preparing the base was therefore followed. The binding material for the upper course was composed of a mixture of molasses, oil and lime.

In certain sections of the country considerable quantities of waste molasses or blackstrap are produced in the manufacture of sugar. This material has but few uses and is therefore sold at a low figure in the neighborhood of the sugar refineries where it is produced. It is of an exceedingly sticky nature and when combined with quicklime produces calcium sucrate, which upon standing sets into a dense sticky cement. This cement is somewhat soluble in water, and for this reason can not in its natural state be used in localities subjected to frequent rains. An attempt was therefore made to waterproof it by the addition of a semiasphaltic oil with which it would be amulsified for the time being. From laboratory experiments a combination of these materials was devised which gave indications of suitability as a road binder. As the policy of the office has always been to further the use of local products in the construction and treatment of local roads whenever possible, it was thought worth while to construct a short experimentl section of road, using this material as a binder in order to determine its practical value. In the neighborhood of Boston, blackstrap molasses is sold at a very much higher figure than in localities near where it is produced, so that the cost of construction of this section of road was much greater than it would be in those localities.

The binder was prepared in a large mortar box by first slaking 320 lbs. of quicklime with 108 gallons of water. As soon as the lime was completely slaked, 92 gallons of molasses was added and thoroughly mixed with it, after which 50 gallons of the semiasphaltic oil was stirred in. While the preparation was still hot it was mixed with the graded stone in the same manner as has been described for the bituminous mixture, except that in this case the stone was not first heated. Eighteen gallons was applied to every 1,310 lbs. of stone, and the concrete thus produced was hauled to the road and laid as soon after mixing as possible. When rolled it produced a firm and resilient surface upon which heavily loaded teams produced no wheel marks one-half hour after it had been laid. Under the action of the roller a small portion of the oil came to the surface, so that a light application of stone chips was required to put the surface in good condition.

The section treated was 351 ft. in length, 186 ft. of which was 17½ ft. wide and 165 ft. 13 ft. wide. The total area covered was 600 sq. yds, and 0.92 gallon of molasses, 0.5 gallon of oil, and 3.2 lbs of lime per square yard was used. The labor item was exceedingly high in this experiment because of the inexperience of the workmen in preparing and handling the material. The cost of molasses was figures at 11 cts. per gallon and of lime at 60 cts. per 100 lbs.

Summary of Experiments Conducted at Newton, Mass.—Besides the experiments already described, one other was made on Cabot St., in which sand was used and covered with a very weak preparation of lime and molasses as a top dressing. This experiment proved a failure.

After three months' wear all of the sections which have been described are in good condition, so that it is possible to compare them satisfactorily. If any comparison were made, however, those sections covered with tarred sand seem to be best, and that constructed with oil as a binder not quite so satisfactory as the others. After a winter's wear, the defects in the least satisfactory section should become apparent, but among those which are in good condition at the beginning of spring it is possible that a much longer time will be required before a choice can be made. In regard to this, as well as all other work of an experimental character, it may be said that the cost was greater than that which would be involved in the construction of long stretches of road where the work could be arranged and carried out more systematically. Table III gives in condensed form the cost data of all of the experiments described.

EARTH—ASPHALT.

In this experiment, which was conducted at Independence, Kan., in 1908, an attempt was made to construct an earth-asphalt road with an artificial asphalt preparation having the following properties:

Specific gravity 25° C./25° C.	0.981
Penetration 77° F. (25° C.) No. 2 N. 5 sec., 100 gms.	257.00
Loss at 212° F. (100° C.) after 5 hours (per cent)	.0.00
Loss at 325° F. (163 — ° C.) after 7 hours (per cent)	.20
Loss at 400° F. (204 + ° C.) after 7 hours (per cent)	1.01
Residue* (per cent)	98.99
Soluble in CS_2 total bitumen (per cent)	99.62
Organic matter insoluble in CS_2 (per cent)	.15
Inorganic matter (per cent)	.23
Total (per cent)	100.00
Bitumen insoluble in CCl_4 (per cent)	0.00
Insoluble in 86° naphtha (per cent)	†20.26

*The residue was practically the same as the original material.

†Per cent total bitumen, 20.34.

This material was used at the request of the manufacturers. A more suitable product could have been obtained by cutting it with crude oil or with a volatile distillate in sufficient quantity to insure a proper absorption by and better mixing with the soil.

Tonopah St., running the length of two city blocks, and Minnehaha St., for three blocks adjoining it, were selected for this experiment. A treatment of some sort was most urgently required, as these streets were almost impassable during winter weather. Tonopah St. for a length of 300 ft. was composed of slate-colored gumbo which proved very difficult to work. The remaining 500 ft. consisted of a huckshot

TABLE III.—COST DATA OF EXPERIMENTS AT NEWTON, MASS.

Experiment No.	Binder applied.	Labor per sq. yd. On road. Cents.	Labor per sq. yd. Mixing. Cents.	No. 1 stone per sq. yd. Cents.	Graded stone per sq. yd. Cents.	Screenings per sq. yd. Cents	Sand per sq. yd. Cents.	Binder per sq. yd. Cents.	Miscellaneous per sq. yd. Cents.	Patching per sq. yd. Cents.	Total cost Per sq. yd. Cents.	Total cost Entire section. Dollars.
1	Asphaltic preparation	20.23	6.76	4.46	5.40	1.00	....	6.97	1.11	0.99	46.92	266.04
2	Asphaltic preparation	20.23	6.76	4.46	5.40	1.00	....	6.97	1.11	.99	46.92	578.05
3	Asphaltic preparation	20.23	6.76	4.46	5.40	1.00	....	6.97	1.11	.99	46.92	499.23
4	Asphaltic preparation and coal-tarred sand	23.10	9.69	4.46	5.40	....	0.64	8.38	1.11	...	52.78	109.25
5	Asphaltic preparation with flush coat of same material	23.59	6.76	4.46	5.40	1.00	....	21.72	1.11	...	64.04	142.81
6	Asphaltic preparation with flush coat of coal tar	26.48	6.76	4.46	5.40	1.00	....	16.06	1.11	...	61.27	53.92
7	Asphaltic preparation	20.23	6.76	4.46	5.40	1.00	....	9.20	1.11	...	48.16	298.11
8	Residual oil	20.23	8.73	4.46	5.40	1.00	....	6.35	1.11	...	47.28	89.36
9	Water-gas tar	20.23	8.14	4.46	5.40	1.00	....	6.21	1.11	...	46.55	120.10
10	Water-gas tar and coal-tarred sand	23.10	11.07	4.46	5.40	....	.64	7.62	1.11	...	53.40	183.70
11	Oil, lime and molasses mixture	26.96	9.02	2.75	7.01	.92	....	14.57	1.11	...	62.34	374.04
	Total		....	....	....	....	....	.....	....	...	.....	3,714.61

clay which pulverized rather easily. With the exception of a few spots of gumbo, Minnehaha St. was composed of disintegrated shale and argillaceous sandstone. Before treatment both streets were graded by city contract and this cost is not included in that of the experiment.

The artificial asphalt was furnished free of charge by the manufacturers at their plant, about three-fourths of a mile distant from the road. It was delivered at a temperature of about 400° F. and run into a tank wagon made by mounting a small boiler, 8 ft. in length by 4 ft. in diameter, upon a farm wagon. In this way no expense was incurred for heating. The material was sprinkled upon the road at a temperature of about 350° F. by means of a 3-in. gas pipe 6 ft. long with one row of one-half inch holes bored at a distance of 1¼ in. from each other, and two rows of one-fourth inch holes similarly spaced. This device was fitted to the outlet of the boiler and rested about one foot above the surface of the road and at right angles to its length. Considerable difficulty was experienced in keeping the holes from becoming clogged, even when the outlet valve was wide open.

The road was plowed to a depth of 6 in. and the earth pulverized as completely as possible with a disk harrow and plank drag. It was found impossible, however, to pulverize the gombo satisfactorily. The asphalt was applied at the rate of three-fourths of a gallon per square yard, after which the road was well harrowed and more asphalt applied as before. The road was again well harrowed and the earth and asphalt moved back and forth across the road with a grader, this method of mixing proving most satisfactory of any that was tried. The road was then plowed to a depth of about 5 in., pulverized, and asphalt applied and mixed as before, after which water was put on until the road became quite muddy. Mixing was continued for some time with the road grader and disk harrow. An attempt was made at this point to use a tamping roller for mixing, but this had to be abandoned, as the spaces between the teeth became completely filled by the time it had traveled 300 ft. The road was left in this condition until it became fairly well dried out, when the tamping roller was tried again. A hard crust had formed on the surface of the section of gumbo and very little good was derived from tamping. The road was then shaped and rolled with an ordinary roller. It was found that the asphalt was not readily absorbed by the soil. Recent heavy rains, however, caused a finished portion of the road to become fairly muddy and traffic then seemed to produce an excellent mixing, so that in time the road may improve. The cost data for the 5,218 sq. yds. constructed are given in Table IV.

TABLE IV.—COST DATA OF EARTH-ASPHALT ROAD, INDEPENDENCE, KAS.

Item	Total cost	Cost per sq. yd.
Preparing road for asphalt	$2[illegible]	$0.0[illegible]6
Applying asphalt	[illegible]	[illegible]
Mixing on road	[illegible]	[illegible]
Tamping and rolling	4[illegible] 40	[illegible]
Sprinkling with water	18 10	.003[illegible]
Loading and unloading roller	6 [illegible]	.001[illegible]
Asphalt*	1 20[illegible]	.2[illegible]10
Total	1 4[illegible]1 1[illegible]	$0.2[illegible]1

*The cost of the asphalt was estimated at $20 per ton and for this purpose the weight per gallon at temperatures [illegible]° F. to [illegible]° F. was calculated at 7½ lbs. The amount of asphalt per square yard at the temperature applied was 2.18 gallons, or at 60° F. was 2.98 gallons. At the latter temperature 1 gallon of the asphalt was found to weigh 8 lbs.

TAR SLAG, TARRED SLAG AND TARRED SLAG LIMESTONE

These experiments were made at Birmingham, Ala., in 1908 on a road known as the Duck Pond road. This is the shortest route from Birmingham to Ensley, and the road is subjected to a very heavy traffic of drays and automobiles. In these experiments the old road was entirely reconstructed. A 24-ft. tar-treated macadam, with 5-ft. shoulders was built and the grades were reduced to less than 5 per cent. The materials employed were blast furnace slag, limestone, and tar. The slag was produced at the neighboring town of Bessemer. It was hard and acidic in character and contained a large percentage of glass. The limestone was quarried and shipped from a point about 10 miles south of Birmingham. The tar was obtained from by-product coke-ovens and was produced at a low temperature. It had the properties given below:

Specific gravity, 25° C./25° C.	1.169
Ammoniacal water, per cent by volume	3.1
Total light oils to 170° C., per cent by volume	16.3
Total dead oils, 170°-270° C., per cent by volume	30.7
Pitch residue by difference, per cent by volume	49.9
Total	100.0
Pitch residue, per cent by weight	55.0
Insoluble in 90 per cent benzol, per cent	6.7

This was a crude coal tar, and when cold about three-fourths of both light oils and dead oils solidified. The pitch residue was dense, lustrous and brittle at ordinary temperature. Had it been practicable to distill off the ammoniacal water and total light oils a much more suitable product would have been obtained for this kind of work.

Experiment No. 1.—Tarred Slag-Limestone Macadam.—In this experiment a section 750 ft. in length was constructed in three courses. The first course was composed of slag as it comes from the pit, placed 5½ in. deep at the center and 4½ in. deep at the edges. After rolling, a second course of the same material was laid 4½ in. deep at the center and 3½ in. deep at the edges. This course was also rolled, after which slag screenings were applied and rolled in. It was noticed that the slag by itself did not bond even when rolled after a heavy rain. After the road had become thoroughly dry, the tar was heated in a 2-barrel kettle and applied at a temperature of about 175° F. It was poured over the surface at the rate of 1 gallon per square yard by means of common watering pots fitted with fan-shaped nozzles. A light course of limestone screenings was then spread over the tar to prevent it from sticking to the roller. The tarred surface was rolled until consolidated as well as possible. The lower courses, however, waved and tended to disrupt the surface bond if rolling was carried on for two long a time.

Experiment No. 2.—Tarred Slag-Limestone Macadam.—For Experiment No. 2 a section 2300 ft. in length was selected. The first course was laid as in the previous experiment, but the second was composed of 1 to 1½ in. crushed limestone placed 4 in. deep at center and 3 in. deep at the endges. After being rolled, a third course of ½ to 1 in. crushed limestone was applied to the depth of 1 in. and rolled until smooth. The tar was then applied as before. After standing for a few days, limestone screenings were applied and rolled in.

Experiment No. 3.—Tarred Slag Macadam.—In Experiment No. 3 a section 450 ft. in length was treated in the same manner as in No. 1, except that the second course was composed of crushed slag which had passed a 1½ in. screen and been retained by a 1 in. screen. This section required the same amount of slag screenings as the first and the immediate results were quite similar. Sections cut from this road showed that the tar had penetrated for about 1½ in. and that the voids in the lower courses had been well filled with fine material.

Experiment No. 4.—Tarred Slag Macadam.—Experiment No. 4 was made upon a section 900 ft. in length, the first two courses of which were laid and rolled in the same manner as was described for No. 1. Tar was applied as before and slag screenings spread after the tar had stood for two or three days. As this was the last part of the road to be constructed, and as the weather conditions at that time were exceedingly unfavorable it was found impossible to finish the section satisfactorily. A length of 175 ft. of this section was treated, however, with a second application of tar at the rate of 0.51 gallon per square yard and produced better results.

Experiment No. 5.—Tar Slag Macadam.—In Experiment No. 5 a section 100 ft. in length was constructed in the same manner as in No. 3, with the exceptions that the second course was only one-half as thick and that a hot mixture of slag and tar was applied to the first course in sufficient quantity to bring the surface to the same grade as in the adjoining section. Slag screenings in the proportion of 25 per cent were added to the coarse slag while being mixed with the tar, and 16 gallons of tar was mixed with every cubic yard of slag. The tar and slag were both heated and mixed in a mastic kettle. Owing to the same conditions as have been described under Experiment No. 4, the results were not satisfactory. The cost data for these experiments will be found in Table V.

EXPERIMENTAL SAND-CLAY ROADS

In the semiarid portions of Kansas and Nebraska there is an extensive area of sand hills. These hills are usually parallel to the rivers and vary in width from a few hundred yards to several miles. They are continually shifted by the winds, and hence road building in this region is a difficult problem. Good road material is scarce and

TABLE V.—MISCELLANEOUS DATA OF EXPERIMENTS AT BIRMINGHAM, ALA.

Item	Cu. yds.	Cost per cu. yd.	Sq. yds.	Cost per sq. yd.*	Total cost
Excavation	21 876 [illegible]	$0.2168		$0.332	$4 735 74
Drains and clearing				[illegible]	[illegible] 60
Slag placed on road (slag and stone sections)	1 167 67	1 [illegible]	[illegible]	[illegible]	1 167 67
Stone placed on road	1 041 9	2 0641	[illegible]	[illegible]	2 162 53
Slag placed on road (slag section)	2 918 9[illegible]	.9992	[illegible] 867	.107	2 916 9[illegible]
Tar†				.014	526 60
Application of tar			12 000	.007	89 82
Engineer, rolling and repairing machinery				.033	39[illegible] 00
Coal, oil, repairs, sprinkling, etc.				.038	460 04
Watchman				.023	279 50
Total					$1[illegible] [illegible]31 45

*The average total cost per square yard was $1.1[illegible].

†The number of gallons of tar applied was 13,7[illegible]0, at a cost of $0.0384 per gallon.

the country is sparsely settled. In many localities there are no road materials except an alkali soil, gypsum clay, or a gumbo-like sedimentary clay.

Experiment at Garden City, Kan.—At this point sand hills run parallel to the Arkansas River on the south side and form a strip nearly 7 miles wide. A careful inspection of the vicinity revealed no available road material except occasional deposits of gypsum clay distributed irregularly across the sandy belt. From two of these deposits was taken the material used in the construction of the road at this place. The first pit was opened about 900 ft. east of the road and the other near the roadside. From the first pit 68 cu. yds. was hauled, but it was then abandoned because of the distance of haul and because the clay showed a lack of binding power. The road was completed with material from the second pit. The farther down in the pit the stickier was the clay and the better it compacted after the addition of sand.

The problem to be solved in this case was the best method of handling the local material, gypsum clay, so as to produce a road with a wearing surface capable of resisting the action of the constant winds, which are generally from the south. For this experiment a section of road 765 ft. long, situated on the slope of a sand hill, was selected.

The clay was hauled directly upon the road, down the center of which a width of 12 ft. had been staked. The clay covering was spread to a depth of about 9 in. immediately after it had been dropped on the road. The clay was hauled over the loads previously deposited and all holes so made were filled at once. Traffic was allowed upon it and this compacted the clay firmly. During the time of hauling the clay no rain fell, but after the hauling was completed a heavy rain soaked the clay and the road was finished as follows. While the road was wet a spike-toothed harrow was put on and the clay completely pulverized. Then five furrows were backfurrowed on each side of the clay, thus raising the sand shoulders above the clay center. A split-log drag was now put on the road and the sand thus raised by plowing was pulled from the shoulders upon the clay and thoroughly incorporated. The road was then smoothed and left for travel.

While the construction of this road followed closely the ordinary method of sand-clay construction, still there were some variations, owing to the peculiar conditions to be met, as has already been explained. It was believed that a surface was necessary which would resist the occasional heavy showers incident to this climate and at the same time the action of the winds. Therefore, the clay having the greatest tenacity was selected. Because of the dryness of the climate it was deemed best to proportion the clay far in excess of the sand. While the clays available may not be altogether desirable, still any clay that will pack under traffic will improve greatly the heavy sands found in this locality.

The cost data of this experiment follow, and the miscellaneous details of all four sand-clay experiments are shown in Table VI.

	Total.	Per cu. yd.
Stripping clay in pit	$ 7.17	$0.024
Plowing up clay in pit	10.50	.040
Loading clay into wagons	33.00	.129
Hauling clay to road	39.50	.154
Spreading clay on road	10.00	.037
Sanding, harrowing, and finishing road	2.33	.009
Cost of clay on road per cu. yd.		.40

The cost per square yard of part clayed was 10 cts. and the rate per mile was $707.45.

TABLE VI.—MISCELLANEOUS DATA OF SAND-CLAY EXPERIMENTS.

Place.	Length of road treated. Feet.	Entire width of road. Feet.	Width of clayed part. Feet.	Depth of clay layer. Ins.	Clay hauled to road. Cu. yds.	Surface clayed Sq. yds.
Garden City	765	30	12	9	256	1,020
Dodge City	9,750	30	14	*11	3,703	15,167
Bucklin	4,271	30	14	12	1,883	6,644
Ford	350	30	16	13	179	622

*Depth of clay and sand.

Experiment at Dodge City, Kans.—The same natural conditions exist here as at Garden City, and the sand hills are on the same side of the river, though only two miles wide. A section of the road leading to Mineola, Kans., was selected, and after the work was started the citizens became much interested and urged that the entire two miles be hard surfaced. This was done.

The general plan of construction at this place was similar to that at Garden City. A deposit of clay was found near the middle of the section to be improved, formed from silt from an old irrigation ditch no longer in use. The water had been allowed to run into a large basin, and about four acres were covered to a depth of 18 ins. with this fine silt. It had thoroughly dried out, so that when plowed up it was in excellent shape for handling with shovels. This material was almost gritless and became very sticky when wet. Although this may be regarded as an unusual condition in this locality, nevertheless results may prove it expedient to use a river silt for road purposes in other irrigation districts when practicable. If this material had not been found the road would have cost fully 50 per cent more.

The entire roadway was 30 ft. wide. In the center of this a 14-ft. track for clay was laid out by plowing two furrows 14 ft. apart. The dirt was thrown out toward the side gutters. Beginning at the middle, the 14-ft. part was plowed by backfurrowing the dirt toward the center. This formed a crown in the middle of the part to be clayed. Next, this was harrowed and the subgrade completed with a small grader. The shoulders were then made by running a furrow outside the subgrade and backing up the first furrow on each side. Two more such furrows were run, and in this way the shoulders were formed at least 10 ins. higher than the subgrade. If the cross section is level, a toothed harrow is excellent to prepare the subgrade after it has been plowed as has been described above. When it is necessary to move material from one side to the other, or to carry material along in the subgrade, a 2-horse grader will be found useful.

After the subgrade had been prepared the clay was hauled and dropped three loads abreast. The center loads followed the center line exactly, and to this end a line of center stakes was set 200 or 300 ft. in advance of the clay hauling. It was then an easy matter to drop the side loads properly. It is best to keep the center loads 30 to 50 ft. in advance of the side loads. In this way three teams may be kept busy at the same time. In order to get a sufficient sand covering upon the road, drag scrapers were used and sand hauled from beyond the borders of the roadway. It was then spread with a harrow and a 2-horse grader evenly over the road and mixed with the dust and fine particles of clay. After a rain the sand was quickly incorporated with the clay. Still more sand was evidently needed, and this was harrowed into the clay as the mass dried and packed under travel. Finally, a large grader was used to shape the road.

As has been stated above, the clay at this place was rather more of an accident than a natural condition of wide extent; still it is of sufficient importance to justify a careful study of its behavior on the road. It would be an easy matter to provide settling basins along irrigation canales where this fine silt could be collected, and after the water had been shut off the clay thus deposited could be hauled upon the road. In this way large quantities of material could be provided, and if its use proves as valuable as indications seem to show, much good may be expected from this source in the improvement of heavy sand roads along irrigation ditches. In this experiment the silt combined readily with the sand when wet and held it firmly. The addition of sand took away its sticky qualities.

The cost data of this experiment follow:

Foreman for job	$ 51.50
Excavation (2,539 cu. yds.)	396.69
Shaping subgrade	70.00
Plowing up clay	54.875
Loading clay into wagons	470.00
Hauling clay to road	608.38
Spreading clay on road	93.00
Harrowing and mixing clay and sand	6.00
Sanding road and building shoulders	107.685
Dressing road with grader	27.00
Work on bridge, timber, etc.	59.53
Repairs, water boy, and sundries	52.75
Cost per square yard of part clayed	.138
Rate per mile	1,135.83

By reference to Table VI it will be seen that 3,703 cu. yds. of clay were used on the road. The itemized cost of this clay was as follows:

	Total.	Per cu. yd. clay.
Plowing up clay	$54.875	$0.015
Loading clay into wagons	470.00	.127
Hauling clay to road	608.38	.164
Spreading clay on road	93.00	.025
Harrowing and mixing clay and sands	6.00	.001
Total		$0.332

Experiment at Bucklin, Kans.—For this experiment a portion of the road leading from Bucklin to Spearville was selected. It was on the south side of the Arkansas River, as in the preceding cases. The general plan of construction was identical with that used at Dodge City, but the clay was of a different quality. At the south end of the road a clay was used which proved to be a kind of buckshot. It hardened well, although the surface appeared to be of a loamy character and blistered badly at first, though later it packed and gave promise of durability. After removing the surface of the clay pit to a depth of 12 ins. the character of the clay changed materially and it promised to be an excellent road material. At first it was feared that it might lack the necessary binding power, but as it was the only material within a mile of the road its use was begun as an experiment. When the pit was lowered 30 ins. the clay became excellent in quality. This pit was loecated at the highest point on the road and its use proved a great economy because of the ease of haul. From a place near the other end of the road an alkali clay was hauled upon the sand at that end. A section 6,771 ft. long was laid out and plowed and the subgrade shaped ready for the clay. Of this distance, a section 4,271 ft. long was improved and a sec-

[illegible] 1,500 ft. [illegible] [illegible] [illegible] the community.

Following are the cost data of this experiment:

Freight on tar	$ [illegible]
Excavation [illegible]	[illegible]
Scraping [illegible]	[illegible]
Loading [illegible]	[illegible]
Loading clay into wagons	[illegible]
Hauling clay to road	[illegible]
Spreading clay on road	[illegible]
Rolling, etc.	[illegible]
[illegible]	[illegible]
Total cost	[illegible]

On this road 1,550 sq. yd. of clay were used, the itemized cost of this portion of the work being as follows:

		Per
	[illegible]	cu. yd.
Plowing up [illegible]	[illegible]	$ [illegible]
Loading clay into wagons	[illegible]	[illegible]
Hauling clay to road	[illegible]	[illegible]
Spreading clay on road	[illegible]	[illegible]
Total		$ [illegible]

Experiment at Ford, Kan.—At Ford a short section forming the south approach to the bridge crossing the Arkansas River was graded and clay added. This was really a matter of grading an incline to the bridge, but as the material for the approach was sand it was necessary to form a hard top surface. This was done by adding clay. The material was gotten from a valley basin where clay had settled. The section of road treated was 350 ft. long, and a bed of clay 16 ft. wide and about 12 ins. deep was put on. The surface was then covered with sand 2 ins. deep and left for traffic to mix. It was frozen hard when placed on the road.

Some of the cost details follow:

Fixing up road [illegible]	$ 47.[illegible]
Plowing, loading and hauling clay	[illegible]
Spreading clay	8.00
Sanding clay	8.00
[illegible] road with grader	[illegible]
Total cost	191.[illegible]

CRUDE TAR, TAR PREPARATIONS, AND OIL EMULSION EXPERIMENTS IN 1907

These experiments were made at Wayland, Mass., in 1907. Thirteen experiments were made with water gas tar, crude coal tar, and refined coal tar, and two with semi-asphaltic oil emulsions. In all experiments but one, surface applications of the materials were made. The treated sections were last inspected in September, 1908, about 13 months after treatment. It should be noted that the winter of 1907-8 was a most severe one from the standpoint of road work, the ground being subjected to numerous and rapid freezings and thawings.

Experiments Nos. 1, 2, 3 and 4; Water Gas Tar.—All four of the sections treated with this material appeared about the same when inspected. The tar had disappeared from the road surface to a great extent, although the sections were in moderately good condition and fairly free from dust. These experiments have demonstrated that crude water gas tar is valuable only as a temporary binder, and that the most satisfactory and at the same time most economical results can only be obtained by retreating the road with light applications whenever the dust becomes excessive.

Experiments Nos. 5, 6 and 7; Crude Coal Tar.—On the sections treated with crude coal tar, Experiments Nos. 5 and 6 were in fair condition. The tar had disappeared from some places and the road looked patchy. There was little dust, however, on these sections. The section similarly treated in Experiment No. 7 was in a much worse condition, although better than before treatment. It was located in the center of the town where traffic conditions were more severe than on the other sections. Much of the tar had disappeared from the center of the street. It was somewhat dusty, [illegible] [illegible] [illegible] [illegible] [illegible]. It was found necessary to make repairs on this section during the winter on account of [illegible] of the surface caused by freezing.

Experiments Nos. 8, 9 and 10; Water Gas Tar and Coal Tar.—The results of Experiment No. 8 were in every way similar to Nos. 5 and 6. In this experiment separate applications of water gas tar and coal tar had been made, though the results [illegible] [illegible] [illegible] from the use of crude water gas tar. In Experiments Nos. 9 and 10 a mixture of coal tar and water gas tar had been applied cold, pea stone being used as a surface dressing for No. 9 and gravel for No. 10. At the time of inspection No. 9 was in slightly better condition than No. 10, although much of the tar had disappeared from both sections. These sections were, however, quite free from dust. It is evident that a mixture of this kind may be considered as a semi-permanent binder, giving nearly as good results as crude coal tar and having the advantage of suitability for cold application.

Experiment No. 11; Special Tar Mixture.—The section treated with this material, while subjected to the same conditions as No. 7, was in somewhat better shape, although by no means satisfactory. It was not free from dust when inspected, but was in much better condition than before treatment. No repairs were required on this section during the winter, although No. 7, adjoining it, had to be patched.

Experiments Nos. 12 and 13; Special Tar Preparation.—In Experiment No. 12 a section of road was resurfaced and the tar preparation applied according to the penetration method. This section was in almost perfect condition when inspected, being well bonded, non-slippery, and dustless. On the whole, this was the most satisfactory experiment made. In Experiment No. 13 the same preparation was applied to the surface of a section of road already in good condition. With the exception of Experiment No. 12, it appeared at the time of inspection better than any of the others, being firm and dustless. A few spots, however, showed signs of disintegration which will probably spread rapidly unless repaired. From these experiments it is evident that a properly refined coal tar is to be greatly preferred to a crude tar. In the experiments reviewed the more lasting results obtained from the former may be accounted for mainly by the absence of ammoniacal liquor and the lower percentages of naphthalene and free carbon, as shown by analyses. In regard to all of these experiments, it may be said that the fall was a most unfavorable one, and that had conditions been normal much better results would have been obtained from those experiments which proved the least successful.

Experiments with Oil Emulsions.—Two semi-asphaltic petroleum emulsions were used as temporary binders in these experiments. On the section treated with emulsion No. 1 no residue could be discovered at the time of inspection, but traces of the oil were apparent on the section treated with emulsion No. 2. It was reported by residents along these sections that the road remained free from dust for [illegible] [illegible], which was very satisfactory, considering the amount of material applied.

[illegible] [illegible] BY SPRINKLING WITH CALCIUM CHLORIDE

These experiments were made at Washington, D. C., in 1907. Solutions of calcium chloride were sprinkled upon a [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]. These applications were made during the summer, and the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] with water. The [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]. No [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible].

ROCK ASPHALT, TAR AND OIL EXPERIMENTS AT BOWLING GREEN, KY., AND [illegible] [illegible] [illegible]

These experiments were made at Bowling Green, Ky., in 1907. The materials used were Kentucky rock asphalt, crude Kentucky petroleum, and a specially prepared residual oil. The results of an inspection made in January, 1909, are given below.

Rock Asphalt Experiment.—In this experiment the rock asphalt was used as a binder and to fill the voids of a rock macadam surface. It was first [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] well as [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]. A small quantity of [illegible] material appeared on the surface, but this had evidently been tracked on from the untreated section. The entire road was smooth, free from ruts, and in only two small places could the underlying [illegible] be seen. These places were, however, not so well bonded as the rest of the surface and in no way inferior to it. On one side of the road the shoulder had settled slightly, leaving a raw edge open to attack from traffic and wash. By raising and consolidating this shoulder the road would be put in almost perfect condition.

Oil Experiments.—The sections treated with the residual oil had been, through mistake, completely covered with gravel shortly after its application, and no result whatever was obtained from its use. As in the Jackson, Tenn., experiment, the use of crude oil on both gravel and macadam roads proved to be of only temporary effect. No trace of the oil was apparent at the time of inspection, but according to a statement made by the city engineer, the amount of dust on these roads in comparison with untreated roads was [illegible] [illegible] [illegible] the latter part of the summer. It might be noted that as a result of these experiments the city of Bowling Green has, during the past summer, treated nearly all of its streets with oil, and considers the result satisfactory.

In 1908 experiments were made at [illegible], Tex., with tars and oils. When last inspected in January, 1909, the following results were reported:

Tar Experiments.—On the [illegible] streets treated with a surface application of [illegible] at about [illegible] [illegible]. This [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] in August, 1908, and [illegible] [illegible] [illegible] [illegible] since that time.

[illegible] treated surface.

The [illegible] during the summer months, when the [illegible] [illegible] [illegible] [illegible] formed

Unclassified and General Articles

Note: This section is devoted to methods and cost articles on construction work not properly coming under any of the preceding classifications.

Methods of Snow-Fighting on Railroads.*

BY A. W. WHEATLEY.

Conditions in various parts of the country, from a snow-fighting standpoint, differ to a considerable extent. For instance, conditions in the middle West differ from those in the extreme Eastern and Western sections of the country, owing to the nature of the snow and the extreme cold which invariably follows a snow-storm or blizzard. Consequently, different methods must be followed in keeping a railroad open.

Care must be taken by the officials of the mechanical department to have snow-plows, in fact all snow-fighting equipment, in readiness at a date not later than November I, knowing that the equipment has been thoroughly overhauled during the summer months, this being a matter of considerable importance; at the same time, operating officials should have snow-fences in good condition.

Crews should be selected for rotary service, and regularly assigned, if necessary. Rotary snow-plows should be fired up and thoroughly tested. This should be repeated occasionally, in the event of machines not being put into actual service. A supply of extra or repair parts should be put into stock and carefully maintained during season, for in many instances roads have been blocked for hours because of not having repair parts to apply to plow to replace those which have failed. Flangers should be applied to locomotives assigned to flanger-service, and thoroughly tested.

Where the old type of wedge-plow attached to a locomotive is used, we feel that it is better to use it in precisely the same way as you would use a Russell or similar type of plow; in other words, disconnect the engine, stripping same all possible, and use live power behind it for pushing. Very little is gained in power by use of the plow-engine, and it is a source of considerable annoyance and expense at the terminals, to say nothing of delays, sometimes resulting in the tying up of a road. When used as a push-plow, and handled by another locomotive, it can be set aside at the completion of its work without taking up a stall in the roundhouse, and when in actual service is not subject to failure; it also eliminates the necessity of taking the plow to the roundhouse for thawing out purposes, etc., and making certain repairs to the engine.

To cope with drifts 15 to 20 ft. high, something besides brute force is required. The old method of bucking drifts of this kind with the wedge plow pushed by several heavy locomotives, resulted in many casualties among the railroad men engaged in the dangerous work. The Rotary is the best adapted for such work, and will bore its way through drifts packed in a hard, icy mass with perfect safety to those operating. For mountain service, because of curves, side drifts and dangers incidental to high speed, it is indispensable.

Assuming that a description of the Rotary will be interesting, we offer the following: The engine consists of two horizontal cylinders, with slide valves actuated by the Walcheart valve gear. The boiler is of the locomotive type, with Belpaire firebox. The wheel is driven by means of bevel gears on the main shaft and on the engine shafts. The wheel is composed of ten hollow cone-shaped scoops, the surfaces of which are perfectly smooth, so that it is impossible for the snow to stick in any way. Each scoop is open its entire length on the front side, through which the snow is taken in. Knives are hinged on each side of the opening, arranged so as to adjust themselves automatically into cutting position.

The wheel is encased in a drum with a square front or hood, which is so designed as to present no dead surface to be forced into the snow. At the bottom, the hood projects only a few inches in advance of the cutting blades at the circumference of the wheel; while at the center of the wheel the knives are the first to encounter the snow. As a result, the whole front of the Rotary is a sharp, cutting edge, and the power required to push the plow is very much decreased. The chute in the top of the drum is provided with an adjustable cover, which can be turned to suit the direction in which the wheel is throwing the snow.

Another excellent feature of the Rotary is the design of the flangers and ice-cutters. It has been proven that, with the ice cutters and flangers in perfect order, it is absolutely impossible for the rotary to be derailed by snow or ice. The ice cutters and flangers are connected by iron rods to cranks on the balance shaft, and may be raised and lowered by means of an air cylinder. An auxiliary steam connection from the boiler supplies steam to the flanger cylinder in case the air pump is disabled while the Rotary is in service.

The flangers are located on the rear end of the frame of the front truck, and are made up of two parts, the wings and the flanger points. The flanger points which go below the rails are bolted to the under side of the bottom of the wings, so that in case they strike an obstruction other than snow or ice, the bolts will be broken off and no other injury done to the flanger. Extra flanger points, with suitable bolts, are carried in the tool box, and it is only necessary to replace the flanger points to put the flanger again in perfect working order. By thus ensuring against delays due to the wrecking of the flangers or the ice cutters, a most important advantage is secured and the efficiency of the rotary greatly increased.

The Rotary is equipped with Westinghouse air brakes, with 9½ in. pump, and large reservoir capable of supplying both air brake cylinder and flanger cylinder.

In active service, three men are required to operate the Rotary—a pilot, an engineer and a fireman. It is needless to state that these men should be carefully selected, having in mind temperament and physical condition.

Except in the most extreme cases, one heavy consolidation locomotive provides sufficient power to push the Rotary.

As the most successful operation of the Rotary depends altogether upon the manner in which it is handled, it is therefore essential that the crew of both the Rotary and the pusher should be especially trained for the work.

Inasmuch as it is often necessary to operate the Rotary for a longer period than it is possible for one crew to continue on duty without being relieved, an extra crew should be trained to handle the machine.

The responsibility of the operation of both Rotary and snow-plow train should rest upon the pilot. He should determine, in all cases, the power required to push the Rotary. Running orders should be addressed to the pilot and engineer. In case a conductor is sent with the snow-plow train, running orders should be addressed to pilot and conductor.

The Rotary should never be coupled ahead of a train. If this is done, the inability to start and stop quickly enough may result in the jamming of the Rotary into a hard bank and disabling it. It has been found by experience that the best practice is to use one heavy engine to push the Rotary instead of two or three light ones. To successfully operate the Rotary, it should be fed gradually, and not bucked, into the snow.

Actual experience has convinced the writer that locomotives with small diameter driving wheels are by far the best adapted, and Rotary plows should be equipped with as large a water tank as possible.

The air brakes on the entire snow-plow train should be operated and controlled by the pilot with the engineer's valve in the pilot house.

The pilot should control and operate the flangers and ice cutters, and should be responsible for their proper working while in service. As previously stated, it has been practically demonstrated that, with flangers and ice cutters in proper working order, it is impossible for the Rotary to be derailed by snow or ice. Too much stress, therefore, cannot be laid upon the necessity of taking every precaution to keep both in working order. Before starting out, the pilot should see if flanger points or shearing bolts in the ice cutters need to be replaced. The flangers should always be raised when running the Rotary over a clear rail or in drawing it back over the line.

The steam whistle on the Rotary should be used for signalling the engineer on the pusher, and the air signal for signalling the engineer on the Rotary.

The engineer on the pusher should never start the train until the pilot has given the proper signal.

Before starting the train, the pilot should first see that the flangers are raised, and then give the signal to the engineer on the Rotary to start the wheel. The signal to start the train should never be given until the wheel of the Rotary has been started and is running in the direction in which the chute is opened.

The engineer on the Rotary should never take his hand off the throttle lever while the train is in motion. The wheel of the Rotary should never be run while it is on a turntable or crossing a bridge or trestle. Because of the overhanging weight at each end, both Rotary and pusher should shut off before entering upon a bridge or trestle.

The Rotary should never be run into a snow bank at a speed of over three or four miles an hour.

When within 50 ft. of a bank the pilot should signal the engineer on the Rotary ahead, which should be the signal for him to regulate the speed of the wheel with the throttle and reverse lever to about 150 revolutions per minute. When about 5 ft. from the bank, the pilot should give the second signal for the Rotary to come ahead, and the engineer should then increase the speed of the wheel. When the Rotary strikes the snow, the pilot should signal the pusher ahead. If he finds the

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*A paper read before the Canadian Railway Club.

Rotary [illegible] power of the pusher, he should give a second signal to come ahead, which should mean that the engineer on the pusher or pushers will increase the power. If the pusher is crowding the Rotary too much, the signal should be given to the engineer of the Rotary to increase the speed of the wheel. In case the pusher is still crowding the Rotary, the pilot should apply the air brakes to check the pusher. If unable to hold the pusher with the brakes, he should give the signal to the engineer of the pusher to shut off, who should respond instantly to avoid stalling the Rotary. When within about 10 ft. of the end of a drift, the pilot should give the engineer on the Rotary the signal to slow down, and when almost out of the bank the signal to shut off, which the engineer on the Rotary should understand to mean slow down to normal speed of the wheel.

In case the Rotary is stalled, the pilot should at once give the signal to the engineer on the pusher to shut off. He should then raise the flanger and signal the pusher to back up, which the engineer should understand to mean to draw back only 4 or 5 ft. from the bank. When again ready to start up he should signal the engineer on the Rotary to come ahead, and, when the wheel is running, should give the signal to start the train, at the same instant giving the signal to increase the speed of the wheel. This rule should be carried out every time a stop is made in a bank.

The Rotary should never be backed into a bank from a distance of more than 4 or 5 ft. If this is done, it is liable to disable the Rotary.

In case the wheel of the Rotary becomes blocked with snow, the pilot should stop the train and give the signal to back up 4 or 5 ft. It is then only necessary for him to loosen the snow between the drum and the scoops, after which the wheel will clear itself.

The Rotary should not be forced through snow deeper than the hood. To attempt this is dangerous, and will result only in serious trouble and unnecessary delay. When the snow is deeper than the hood of the Rotary, the top of the bank should be shovelled off for a distance of 10 or 15 ft. before the Rotary is brought into operation.

When operating in light snow, the wheel of the Rotary should not be run at a speed sufficient to throw the snow [illegible] of the chute and clear of the tracks.

When cleaning side tracks or yards with the Rotary, a signal man should be stationed 5 or 10 ft. from the switch which the Rotary has to pass, and on the opposite side of the track from which the snow has to be thrown. This will enable the pilot to know when to raise the flanger and ice cutters.

The pilot should never reverse the wheel when the Rotary is in a bank. If necessary to reverse the wheel and throw the snow on the opposite side of the track, this should be done while running from one bank to another.

The engineer on the Rotary should watch carefully the height of the water in the boiler, as the rate of speed at which the engines are run will pull the water out of the boiler if it is allowed to get too high.

The Russell or Wedge plows render very satisfactory service where the snow is not too heavy or deep, and the best results are obtained when manipulated at moderately high speed. These plows can be used to best advantage for keeping the track clear when conditions warrant the tying up of traffic during a severe storm or blizzard. In this respect the division officers are called upon to display rare judgment. Many mistakes have been made by the [illegible] relating to the tie up [illegible] and then the "Flying Squadron" of [illegible] [illegible] to keep the road open, resulting in the stalling of trains and a complete tie up of the railroad. The advice of section foremen and others in this respect is at times very valuable, because of their knowledge secured by years of experience, and the fact that they are on the ground.

Many railroads follow the practice of equipping a large number of locomotives with flangers on each district, but the writer feels that better results can be obtained by equipping few small locomotives with flangers and assigning them to flanger service. Seldom is satisfactory service rendered by flangers on locomotives regularly assigned to road service, the exception to this, however, being branch line service. In yards, we feel that at least one switching engine should be equipped with flanger, as a clear rail and flange is of as much importance in the yard as on the main line. We feel that not enough attention is given to yards, and the importance of clear flange not fully appreciated.

Snow fences are of inestimable value in a country where bad storms are encountered, and the snow likely to drift. The maintenance of snow fences is a matter of considerable importance. Many tie-ups or blockades have been caused by neglect or failure to have snow fences in first class condition. In sections of the country subject to severe winters, it is not uncommon to have two or three mild, or open, winters in succession. This tends to make divisional officers indifferent to snow fences, and the first thing they know a severe storm is upon them, and their portion of the road is buried, resulting in losses of thousands of dollars to the railroad company.

Little can be said on this subject applicable to the extreme eastern and western sections of the country. Such extreme measures are, of course, unnecessary, but in flanging service, conditions are about the same, therefore, what has been said in this respect can be applied to all sections of the country subject to heavy snows.

Methods and Cost of Making Triangulation and Plane Table Surveys, Grand Valley Irrigation Project.*

During the spring of 1908 a triangulation system consisting of 18 signals and controlling about 150 square miles was installed on the Grand Valley Project and during the field season of the same year a plane table survey of approximately 97 square miles was made and maps prepared on a scale of 1 in. to 1,000 ft. with 10 ft. contour intervals. A detailed record of expenditures was kept and the itemized costs are shown in tables I and II.

In the triangulation survey the signals consisted of 2 by 4-in. posts 14 ft. high erected over pieces of ¾ in. gas pipe driven from 18 to 24 in. in the ground and braced by three guy wires to each post. The signals were [illegible] [illegible] and where [illegible] were required more frequently or [illegible] [illegible] outside of the [illegible] [illegible] the charge for such work was made against the topographic mapping. The cost of triangulation survey also includes the cost of measuring base lines and of making [illegible] [illegible]. No camp was established and subsistence was furnished at hotels and farm houses in the vicinity.

TABLE I.—COST OF TRIANGULATION SURVEY, GRAND VALLEY PROJECT.

Distribution	Av. time per sq. mi., dys.	Rate per day	Cost per sq. mi.
Triangulator	.11	$[illegible]	$[illegible]
Transitman	.14	[illegible]	46
Office engineer	[illegible]	[illegible]	14
Recorder	[illegible]	[illegible]	15
Flagman	[illegible]	[illegible]	[illegible]
Computer	[illegible]	[illegible]	12
Draftsman	[illegible]	[illegible]	[illegible]
Hired horses	[illegible]	[illegible]	[illegible]
Government horses (depreciation)	[illegible]	[illegible]	[illegible]
Depreciation of equipment			[illegible]
Travel			[illegible]
Subsistence			29
Supplies, miscellaneous			18
Supplies, stakes and monuments		[illegible]	45
Supplies, repairs		[illegible]	[illegible]
Supplies, forage		[illegible]	12
Total cost per square mile			[illegible]

In the plane table survey the field party usually consisted of one plane table man, one recorder and two rodmen, but at times a driver was necessary for teams used by level and topographic parties. The camp teamster hauled the supplies necessary and the men furnished their own subsistence by organizing a mess. The cost of hay was $15 per ton and of oats $1.60 per hundred weight. The area mapped was fairly rough on the average, but the cost was quite variable. On level mesas the cost was as low as $18 per square mile, but where the area mapped consisted of small fruit farms with numerous buildings, roads, fences and irrigation and waste ditches, the cost ran as high as $75 to $80 per square mile.

TABLE II.—COST OF PLANE TABLE TOPOGRAPHIC SURVEY, GRAND VALLEY PROJECT.

Distribution	Av. time per sq. mi., dys.	Rate per day	Cost per sq. mi.
Project office expense			$1 63
Transitman	[illegible]	$[illegible]	[illegible]
Flagman	[illegible]	[illegible]	[illegible]
Levelman	[illegible]	[illegible]	1 41
Level rodman	[illegible]	[illegible]	1 15
Driver	[illegible]	[illegible]	63
Topographer	[illegible]	[illegible]	[illegible]
Recorder	[illegible]	[illegible]	[illegible]
Stadia rodman	[illegible]	[illegible]	12 32
Hired horses	[illegible]	[illegible]	2 93
Government horses (depreciation)	[illegible]		1 21
Computer	[illegible]	[illegible]	[illegible]
Draftsman (chief of party)	[illegible]	[illegible]	1 93
Camp cook and teamster	[illegible]	[illegible]	[illegible]
Depreciation of equipment			[illegible]
Veterinary service			[illegible]
Supplies, general			[illegible]
Supplies, stakes and monuments			63
Supplies, repairs			51
Supplies, forage			[illegible]
Supplies, [illegible]			[illegible]
Traveling expenses for field party			[illegible]
Subsistence for field parties remote from camp			41
Total cost per square mile			[illegible]

The combined output of the dredges of the Atlantic and Pacific Divisions of the Isthmian Canal for April amounted to [illegible] cu. yds. as compared with [illegible] cu. yds. for March, a decrease of [illegible] cu. yds. only.

Three contracts for work on the New York State Barge Canal involving an estimated expenditure of $[illegible] are now being advertised.

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*Reprinted from the "Reclamation Record" for May, 1909.

Cost of Constructing a Wood Flume 4,303 Feet Long, Klamath Irrigation Project.*

The flume is 4,303 ft. long, and has an inside width of 11 ft. and inside height of 5½ ft.; it rests on concrete piers with rubble-stone foundations, and is built of red fir lumber. Of Class 1 lumber, for the framework of the flume, 442,000 ft. B. M. were purchased at $15.50 per thousand, delivered. Measurement after construction, however, showed only 438,000 ft. B. M. in place, and thus indicated a waste of 4,000 ft. B. M. Of Class 2 lumber, for lining the flume, 60,000 ft. B. M. were purchased at $30.50 per thousand delivered, and 227,000 ft. B. M. at $19 per thousand, making a total purchase of 287,000 ft. B. M. Measurement after construction showed 284,200 ft. B. M. in place, thus indicating a waste of 2,800 ft. B. M.

The concrete piers and stone foundations were built by force account. The piers, 1,091 in number, are 18 ins. high, 24 ins. square at the base, and 12 ins. square at the top, and rest on rubble foundations 3 ft. square.

The total costs on which the tabulated unit costs are based are $21,000 for the flume proper and $6,995.88 for the foundations; in addition, however, there were costs, not distributed in the unit costs, of $174.96 for a spillway and $347.54 for miscellaneous expenditures, making a total cost for the whole structure of $28,518.38, or $6.64 per lin. ft. of flume.

KLAMATH PROJECT, TIMBER FLUME, UNIT COSTS.

Distribution of cost.	Lumber in place, per M ft. B. M.		Flume per lin. ft. 4,303 ft.
	Class 1. 438,000 ft. B. M.	Class 2. 284,200 ft. B. M.	
Carpenter work...			
Superintendence ..	$0.46	$1.02	$0.11
Labor:			
Carpenter work ...	5.97	4.83	.93
Distributing timbers	.63	.63	.11
Miscellaneous	.21	.17	.03
Material:			
Lumber delivered..	15.64	21.60	3.02
Bolts and washers.	.36	....	.04
Nails and spikes..	.94	.94	.16
Engineering and inspection	2.91	2.91	.50
Totals for flume proper	$27.12	$32.10	$4.90
Piers and foundations..................			1.62
			$6.52

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*Reprinted from the "Reclamation Record" for May, 1909.

The grand total of Isthmian Canal excavation during the month of April was 3,454,649 cu. yds., 607,983 cu. yds. less than the total for March, 1909, the month in which the highest record since American occupation was made. Of the 3,454,649 cu. yds., 3,343,709 were chargeable to actual canal construction and 110,940 to "plant." The amount removed from the canal prism was 2,985,134 cu. yds. There were taken out by steam shovels 2,137,851 cu. yds., and by dredges 1,316,788. The daily average excavation was 138,185 cu. yds. There were 25 working days during the month, against 27 in March. The mean rainfall for the month in the territory in which excavation was in progress was 4.36 ins. as compared with 1.1 ins. the previous month.

Recently some natural cement concrete work in the habor at Brest, France, was removed. This concrete had been covered with sea-water for 100 years. Iron bars embedded in the concrete did not show the least indication of rust, showing that concrete is a perfect preservative of iron.

Personals.

Mr. Clay Belsley has been appointed City Engineer of Peoria, Ill.

Mr. Charles W. Comstock has been appointed State Engineer of Colorado.

Mr. A. L. Webster has been appointed City Engineer of Wheaton, Ill., and has also been elected County Surveyor of Du Page County, Ill.

Mr. Alexander Potter, consulting and constructing engineer, has removed his office from 143 Liberty St., New York City, to 114 Liberty St., that city.

C. O. Nutter has resigned his position in the City Engineer's Department of Wausau, Wis., to accept a position with the U. S. Government as Timber Cruiser.

Mr. F. W. McKellip, who has for several years been connected with the Engineering Department of the Great Northern Railway, has been elected City Engineer of Faribault, Minn.

T. Kennard Thomson, M. Am. Soc. C. E., Consulting Engineer, 50 Church street, New York, has been retained by the Erie R. R. as Consulting and Supervising Engineer for the Penhorn Creek Viaduct.

Mr. F. L. Nicholson has been appointed Chief Engineer of the Norfolk & Southern Ry., in charge of construction and maintenance of way and structures. His headquarters will be at Norfolk, Va.

Mr. M. L. Newton, Chief Engineer of the Waterloo, Cedar Falls & Northern Ry., has been appointed Consulting Engineer. Mr. T. E. Rust, heretofore Assistant Engineer of the Chicago Great Western Ry., succeeds Mr. Newton.

Mr. F. C. Englesing, of Port Gibson, Miss., is now in charge of locating the Madeira-Mamore Railway in Brazil. Mr. P. H. Ashmead is Chief Engineer, and Mr. Englesing is Assistant Chief Engineer, having charge of the work in the field. May & Jekyll are contractors for this road.

Mr. M. S. Ketchum, M. Am. Soc. C. E., dean of the College of Engineering and professor of Civil Engineering in the University of Colorado, has been granted a leave of absence for the next college year by the regents of that institution. During his absence Professor Ketchum will be associated with Mr. H. S. Crocker, M. Am. Soc. C. E., Consulting Engineer, 811 17th St., Denver, Colo.

Mr. Frank L. Getman, Assoc. M. Am. Soc. C. E., and Mr. Thomas M. Keene, of Havana, Cuba, have entered into partnership under the firm name of T. M. Keene & Co., with headquarters at Havana. The new firm will deal in construction supplies and engage in general engineering and contracting. Both Mr. Getman and Mr. Keene were connected with the office of the City Engineer of Havana during the first American occupation.

Patrick H. Hunt, a prominent contractor of Decatur, Ill., died May 19 at his home in that city. Mr. Hunt was born in 1844 in Ireland. He came to Decatur in 1880, where he opened a marble shop and engaged in erecting monuments and furnishing building materials. From this he branched out into a general contracting business, his firm laying the first brick pavements in Decatur, Springfield, Lincoln, Bloomington, Taylorville, Tuscola and many other towns and cities in Illinois. He also built the main sewer system in Decatur.

The seventeenth annual convention of the Society for the Promotion of Engineering Education will be held at Columbia University and Pratt Institute, in New York and Brooklyn, June 24-26. The time and place for the convention have been chosen with the idea of making it a convenient place of meeting for all who wish to attend the convention of the American Institute of Electrical Engineers, the American Society for Testing Materials or the American Society of Civil Engineers. In addition to contributed articles, there will be presented the "Report of the Joint Committee of Engineering Societies on Engineering Education," by Dugald C. Jackson; "Report of the Committee on Technical Books for Libraries," by Arthur H. Ford; "Report of the Committee on Engineering Degrees," by Wm. F. M. Goss; "Report of the Committee on Entrance Requirements," by Robert Fletcher. A special session will be devoted to the discussion of engineering mathematics by the committee of fifteen appointed at the Chicago meeting of the American Association for the Advancement of Science. This committee has been asked to prepare a special report for the 1909 meeting of the Society for the Promotion of Engineering Education.

Catalogs Worth Having.

Engineers and contractors should have on file the latest catalogs of machines, tools and supplies that they use. In sending for catalogs reviewed or advertised in this paper, you will confer a favor on us if you will write direct to the advertisers and state that you saw the catalog mentioned in ENGINEERING-CONTRACTING. If you are in the market for tools, machinery or supplies, tell us and we will notify promptly the leading manufacturers.

No. 1242. **Hoisting Engines and Derricks.**—American Hoist & Derrick Company, St. Paul, Minn.

This is a large and very handsomely printed catalog of the complete line of derricks, hoisting engines and hoisting machinery and appliances which are manufactured by the above named company. Each of the machines is illustrated and briefly described and tables of dimensions, capacities, weight, etc., are given. All contractors making use of machinery of this character should have this catalog on file.

No. 1243. **Portable Tools and Machinery.**—Stow Flexible Shaft Co., 2228 Buttonwood St., Philadelphia, Pa.

This is a catalog of Stow Flexible Shaft, Portable Motors, Drills, Grinders, Polishers, etc. The various tools and devices are briefly described. Tables of dimensions, capacity and prices are given.

No. 1244. **Weight Computers.**—The Engineers' Equipment Co., 14 South Broad St., Philadelphia, Pa.

The machine described in this 4-page circular has been designed to compute weights of structural shapes. The machine consists of two discs, one rotating on the other, each disc being marked with a logarithmic scale representing the dimensions in feet and inches of the various shapes and results in pounds. One setting of the machine enables the weight of any plate, angle or other shape to be computed at once.

No. 1245. **Power Pumps.**—The Goulds Mfg. Co., Seneca Falls, N. Y.

This is an unusually handsome general catalog of the various kinds of power pumps manufactured by the company named. The catalog contains 191 pages. It begins with a discussion of the principle of triplex power pumps, illustrated by diagrams. There follows a comparison in the cost of pumping and the application of power pumps to general water supply, hydraulic elevators, boiler feeding, power stations and water supply for large mills. Each type of pump is illustrated, specifications are given and a table presented showing capacities, sizes, etc. The catalog concludes with a large number of hydraulic tables and other useful data for pumping engineers.

No. 1246. **Flexible Steel-Armored Hose.**—Sprague Electric Co., 527 West 34th St., New York, N. Y.

The steel-armored hose described in this pamphlet consists of the best quality of rubber hose closely covered with a metal armor composed of a single strap of highly galvanized steel wound around the hose so as to interlock. This armored hose is suitable for drilling and contract work of all kinds where compressed air is to be conveyed and where ordinary hose fails quickly, due to the abuse which it receives.

No. 1247. **Deep Well Pumps.**—Keystone Driller Co., Beaver Falls, Pa.

This little 32-page pamphlet illustrates and describes a line of deep well pumps manufactured by the company named. Special claims are made for the efficiency of these pumps. The pamphlet concludes with a number of useful tables and other data of value to pump men.

No. 1248. **Traction Engines.** — Reeves & Co., Columbus, Ind.

This 48-page pamphlet is entitled "Plowing With Traction Engines." Illustrations show the method of attaching plows, both single and gang, and the text describes the methods which should be followed to get successful results. Photographs are given showing the cost of plowing with traction engines.

No. 1249. **Drawing Tables.**—Geo. L. Kopp & Co., 704 Smithfield St., Pittsburg, Pa.

This little circular illustrates, describes and gives prices of the full line of drawing tables manufactured by the company named.

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The Dawn of the Era of the Agricultural Engineer and the Application of Cost Analysis to Farming.

The application of cost analysis to farming marks another step in the triumphal progress of cost data and the revolution in managerial methods effected thereby. Elsewhere in this issue we give abstracts from two recent bulletins issued by the U. S. Department of Agriculture relating to the cost of producing farm products in Minnesota. The bulletins give the itemized unit costs of raising all the common cereals, hay, potatoes, etc., and of producing dairy products and live stock. The data have been carefully gathered during the years 1902 to 1907 on some 75 farms, and form the most comprehensive summary of analyzed farm costs that have ever been printed, so far as we know. With these data as a basis for the further study of farm economics, it is no exaggeration to say that the age of the agricultural engineer has fairly dawned.

It may strike one at first as being somewhat fantastic to call a farmer an engineer, but the average farmer of the near future is to be nothing less than an engineer if he is to succeed in the struggle for existence. He is to be the cost analysis type of engineer—one who records every item of cost and analyzes the records with a view to securing a minimum unit cost of production. May it not happen that many a civil engineer will find this sort of engineering—cost analysis applied to agriculture—a splendid field for the exercise of his talents?

Possibly many engineering contractors will find it profitable to combine farming with contracting, for, as one such contractor-farmer remarked to the writer, "when it rains it is good for the crops, and when it is dry it is good for contract work," so that he is always happy no matter what the weather.

Certainly the contractor whose work consists largely in teaming will often find it profitable to own a farm where he can raise not only feed for his horses but the horses themselves. If the same business methods were applied by a contractor to his farm as he applies to his contract work, there is little doubt that he would thus make two profits where he now makes one.

Some Recent "Evidence" Against Concrete Construction.

April foolery seems to have unwittingly crept into the May issues of a number of our contemporaries. In the May "McClure's" a writer who is named to us as an expert tells us that the famous concrete piles in Baltimore Bay are rotting at the water's surface and gives the [illegible] [illegible]: "Concrete as the modern reinforced variety has been the cause of more bitter disappointment than any other material." To whom? We would not be [illegible] but the [illegible] is strong. We [illegible] [illegible] [illegible] [illegible]. The "[illegible] Record" [illegible] [illegible] that concrete [illegible] [illegible] the most reliable expert [illegible] [illegible] [illegible] according to the [illegible] [illegible] [illegible] [illegible]. If this cannot be prevented [illegible] [illegible] [illegible], the [illegible] [illegible] be [illegible]. [illegible] [illegible] [illegible] [illegible]. [illegible] [illegible] "Clay Worker," [illegible] [illegible] May [illegible] [illegible] [illegible] the "Concrete Bridge failure at Peoria" and draws from the wreckage this wisdom: "The present and fair degree of safety in [illegible] [illegible] concrete construction is greatly exaggerated in [illegible], nothing but [illegible] that should be done. In fact it required [illegible] [illegible] [illegible] that are commonly practiced. With [illegible] determination [illegible] [illegible] whatever may happen the 'Clay Worker' [illegible] [illegible].

"It concrete has its place in the world and its mission to fill, but when it is forced out into the field of steel and clay products [illegible] certain limited uses it becomes in many instances the most expensive form of building that could be undertaken. This is one instance of it. Its use in the bridge at Peoria because the builders got for an immense sum of money and have nothing for it but a mass of wreckage. It matters not just where they discover the fault, nor how it is pointed out if this had been done or that had not been done it would not have happened, the fact remains that it is an expensive experiment that will not likely be tried again by the same people."

It is so evident that our contemporary regards the inroads into "the field of steel and clay products" of the concrete worker more in sorrow than in anger that our shafts are blunted. Moreover it is a little difficult and not very useful to argue against one who so seriously contends that no matter what was at fault concrete is to blame. We may mention however, that unless somewhat more argument than is evidenced by the remarks which we have quoted shall distinguish the critics of concrete construction it will probably continue to "trample out into the field of steel and clay products."

Expressions of Opinion as to "Contract vs. Day Labor" by Members of The American Society of Civil Engineers.

Every now and then a paper is published in the transactions of some engineering society advocating the doing of public work by day labor, or [illegible] [illegible] of the [illegible] editorial advocacy of day labor [illegible] [illegible] [illegible] like the [illegible] [illegible] [illegible] [illegible] in "Engineering News," "The Contractor" and other journals.

[illegible] (1905) [illegible] appeared in the Transactions of the American Society of Civil Engineers a paper by Mr. A. W. [illegible] on the "Cost of Sewer Construction, Denver, Colorado," [illegible] which were given and intended to prove the economy of day labor as compared with contract work. Doubtless the author was

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somewhat surprised to find not a single out and out supporter of his contention among all the members of the society who discussed his paper. On the other hand, the day labor system was unanimously condemned as a system to be applied in general to city work. Some of the expressions of opinion are not without interest even now, coming as they do from men high in the profession. We quote:

> Most cities began their public works by the day labor plan, but have been forced to adopt the contract system in self-defense. —Foster Crowell, M. Am. Soc. C. E.
>
> Contract work is more desirable and cheaper as a rule than work by the day.—Henry Goldmark, M. Am. Soc. C. E.
>
> The writer's experience has been that sewer work generally costs a city less by contract than by day labor.—William B. Landreth, M. Am. Soc. C. E.
>
> The tabulated results [given in Mr. Follett's article] as to cost do not show any striking gain over that of contract work in this case. This is one of a few instances where experiments of this kind have been successful. In probably seven cases out of ten the political tendencies of boards made up wholly of scheming politicians to give sinecures to political hangers on would have largely increased the cost of the work.—Andrew Rosewater, M. Am. Soc. C. E.
>
> It is the writer's opinioin that in most cities public work can be done to better advantage and at less cost by contract than by hired labor.—G. T. Nelles, M. Am. Soc. C. E.

We may add that the Denver sewers, under discussion, were large brick sewers, and that each brick mason averaged 2,080 brick per 8-hr. day, wages being $4, which is far and away better than the usual output on day labor construction, but less than half what many contractors secure from their bricklayers on sewer work.

It should also be pointed out that a strenuous effort was made by the city officials in this case to prove that day labor work would be the most economic for all sewer construction to be done in the future, and they were not only free to alter the specifications to attain their end, but naturally prompted to do so by self-interest. In discussing this feature of the case, Mr. G. T. Nelles, M. Am. Soc. C. E., said:

> Another important factor in the cost of work done under proper supervision in this manner by cities is the fact that they do not enter into a binding contract with themselves to do the work in a fixed manner, and under rigid specifications, as is the case when work is done by contract. On the contrary, they are always at liberty to make such change in methods or materials as experience may prove to be beneficial and economical to the work. Under the contract system it is rarely possible to make such changes, no matter how desirable they may be, without raising a cry of fraud or violating some of the terms of the contract. As a consequence whenever there is a choice of materials or methods under the contract system, *the most expensive to the contractor is usually adopted.*

We have italicized this last clause, for, unfortunately, it expresses the truth about the tendency on the part of many engineers to exact not merely the last pound of flesh, but to call for an avoirdupois pound, although the supecifications might well be interpreted to refer to a Troy pound. This particular feature of contract work is perhaps the one most worthy of careful consideration by the engineer who aims to secure low bids from reliable firms. There is but one way of accomplishing this end, namely, by preparing specifications with as great care as is given to the work of making the drawings. Sewer specifications are, as a rule, particularly weak in all that relates to the excavation of materials. Generally no soundings or test pits are made by the engineers, and no classification of materials, other than "earth" and "rock" is given. Not only is there no sub-surface survey, but there is not even a fair attempt in the specifications to provide for payment based upon what may actually be encountered. Practically all the "changes," to which Mr. Nelles refers, would be unnecessary were proper sub-surface surveys made in advance of making the design and drawing the specifications.

That contract work is free from flaws we do not contend, but we do maintain that the flaws to be found in the contract system are not only infinitely less objectionable than those in the day labor system, but that the flaws are really the fault of the engineers themselves.

"What," says some one, "will you blame the dishonesty of certain contractors upon engineers?"

"Will you also assert that lawsuits brought by certain other contractors are the fault of the engineers?"

And our answer to each of these questions is, Yes.

Specifications so drawn as to place all burden of doubt upon contractors necessarily breed a class of contractors who are not business men so much as they are gamblers, or politicians who count upon their "pull" to save them from financial loss in case the conditions prove to be worse than anticipated. Many sewer specifications fall under this class, for the reason above given.

A clear, complete, fair specification, if universal on contract work, would soon eliminate such gamblers and politicians as now form part of the number of men in the contracting business, for gamblers and politicians do not have the business ability to compete with the modern contractor.

As for lawsuits, they are the fruit not only of ill prepared specifications but of the class of contractors that such specifications breed.

In our issue of May 5 we had occasion to refer to the record of that great English engineer, Telford, who built hundreds of miles of roads by contract without a single lawsuit; and, we may add, lawsuits over road work are now comparatively rare in our American states where the engineering departments have worked out good specifications.

It is particularly noticeable that the great majority of lawsuits brought by contractors arise over excavation, or over changes in construction necessitated by the discovery of unexpected conditions when the excavations were made. This emphasizes the importance of making sub-surface surveys, as we have termed the work of digging test pits, drilling, sounding, and otherwise exploring the ground. Sewer work particularly requires this sort of engineering investigation prior to planning the construction and writing the specifications that are to govern it.

While several of the members of the American Society of Civil Engineers spoke strongly about the influence of politicians on day labor work, and while this influence is generally a large factor in running up the cost of work done by day labor, it is of less importance, in our judgment, than the fact that men are so constituted that they will not do as much work for a large, impersonal corporation as they will for an individual.

In addition to this, and possibly of greater weight, is the fact that no method has yet been devised that is as effective as the old competitive system in bringing the most capable managers of men quickly and certainly to the front. Political appointments, elections and civil service examinations—the only three existing methods of selecting public servants—are all far from being satisfactory as a means of securing the best men for managerial positions, or, indeed, for any position.

The contracting system, however, furnishes a large number of competing managers of men, all striving to devise the most economic methods, all urging their men to greater activity, all dependent entirely upon their brains and energy for their profits (= salaries), all carrying out the great plan of evolution by competitive strife.

Such a system stimulates the inventive faculties of men—what government or city employe has ever invented a single labor saving device of importance in the construction world?

The contract system rapidly weeds out the incompetents; for no political sinecure, no holding of office during good behavior, no civil service protection, nothing can shield the contractor from quick leveling to the ranks, save his own energy, intelligence and natural aptitude for construction management.

The eleven Lidgerwood unloaders in the Central Division of the Isthmian Canal, during the month of April, unloaded 2,979 trains, aggregating 52,167 cars. Of this number 1,455 trains, composed of 24,735 cars, were unloaded by the five unloaders at Tabernilla; 621 trains, composed of 11,178 cars, were unloaded by three unloaders at the Miraflores dumps, and 903 trains, composed of 16,254 cars, were unloaded by three unloaders at Balboa. As all the cars were of 20-yd. capacity, the material unloaded represented about 1,043,340 cu. yds.

The Northwestern Cement Products association will hold its next annual convention beginning February 28, and ending March 4, 1910.

Concrete and Reinforced Concrete Section

Note:—This section is devoted to methods and cost of constructing concrete and reinforced concrete structures. It will cover the selection, testing and proportioning of concrete materials; laboratory tests of concrete; concrete mixing, transportation and placing; fabrication and placing of reinforcement, and form construction and erection. It will also contain articles on new and interesting developments in the design of reinforced concrete.

Hints for Inspectors of Concrete Work.

VI

Concreting in Freezing Weather.

Concrete work can be safely done in freezing weather if precautions are taken to counteract the action of frost. Three methods are commonly employed to accomplish this result: (1) Add some substance to the mixing water which produces a brine or emulsion which freezes at some temperature below 32° F., determined by the substance added and the richness of the brine. (2) Heating the concrete materials so as to delay the action of frost until the concrete has had time to set. (3) Housing in the work and supplying artificial heat until the concrete has had time to set. Any combination of these three methods may also be employed. Methods one and two have rather narrow limitations of efficiency, but the third method can be used with any degree of frost. Its cost is great, however, so that it is employed only under special conditions.

Adding Substances to Mixing Water.—See that no substance is added to the mixing water, the effect of which on the concrete is not well known. If any other substance than sodium chloride (common salt) or calcium chloride is proposed for the purpose, see that the approval of the engineer is had before its use is permitted.

Salt in Mixing Water.—See that the amount of salt used in mixing water to reduce the freezing temperature does not exceed in amount 10 per cent by weight of the water. Tests show that the strength of cement is injured when mixed with water having an excess of 10 per cent by weight of added salt. It is wise to keep the salt well below 10 per cent. See that the salt addition is determined by actual weight; such determinations as enough salt to "float an egg" or to "float a potato" are untrustworthy—it takes 15 per cent of salt to "float an egg." A good rule to follow is: Add 1 per cent of salt by weight for each degree Fahrenheit below 32° up to a maximum of 10 per cent.

Calcium Chloride in Mixing Water.—It is probable that the best all around results with the addition of calcium chloride are secured when the addition is about 2 per cent by volume of the mortar. This is substantially a 15 to 20 per cent solution, the freezing point of which is 14° F. to −2° F. Richer solutions quicken the set of the cement and the strength of the mortar is reduced as compared with the 2 per cent solution.

Heating Concrete Materials.—See that concrete materials—sand, stone and water—are not heated to excess. Ordinarily the heat cannot be so great as to injure the material itself, but it may be great enough to hasten the setting of the cement so much as to cause trouble or to so dry out the stone that it will absorb enough water to rob the cement of necessary moisture in dry mixtures.

Frozen Lumps in Concrete.—See that lumps of frozen sand and stone do not get into the mixture in freezing weather. The use of hot mixing water cannot be depended upon always to thaw such lumps.

Covering the Concrete.—See that the concrete is protected from loss of heat until set, by covering it so as to prevent radiation of the heat. Tar paper nailed to the outside of wall form studding, so as to form a dead air space, coverings of hay or straw or a wood covering on floors, etc., are among the means possible. See that manure is not used; it keeps the concrete warm, but it also stains it and invites disintegration.

Artificial Heaters.—See that the concrete and the forms are not allowed to dry out when artificial heaters like salamanders or brick ovens are used to keep the work warm. Moisture is essential to the proper setting of concrete, and the loss due to evaporation from concrete and forms by dry heat must be replaced by sprinkling or other means.

Finishing Surfaces.

Special surface finishes are often required. Specifications should be particular and explicit regarding the character and the nicety of the finish required. If they are not, the inspector should learn from the engineer the quality of work he has in mind and should see that the contractor clearly understands the requirements. Perfection of finish is a matter of attention and skillful workmanship, and the inspector has chiefly to watch the workmen. Finishes are of two classes: (1) Those in which the molded surface is treated after the forms are removed; (2) those in which the molding is so done that the finish is a part of the molding process. Faults in finishes of the second class must be prevented during molding by careful workmanship, for after the concrete has set they can be remedied only by patching, which is unsatisfactory, or by giving the whole surface one of the finishes belonging in the first class.

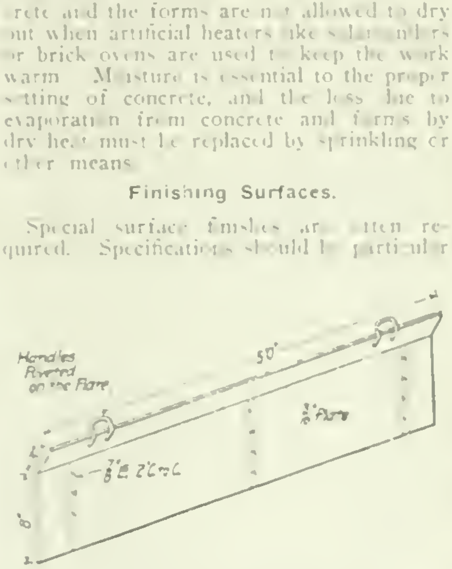

Fig. 1—Facing Form.

Spaded Finish.—See that the coarse aggregate is brought well back from the face and that the fine mortar is flushed well against the forms. Spading is best done with a special flat bladed spade, having the blade perforated with holes or slots, which will screen back the stones and allow the mortar to pass but the ordinary spade or shovel can be used. The spade is shoved down between concrete and the forms and the stones are pushed back from the face.

Spaded and Troweled Faces.—See that the coarse aggregate is well pushed back from the face of the form to allow the mortar to flush to the surface. See that the forms are stripped while the concrete is still green enough to be rubbed down with a trowel.

Mortar Face Finish.—See that the facing mortar and the concrete backing are placed at the same time and are tamped together. See that the tamping is not so hard that pieces of stone are forced through the facing of mortar to the surface, but that it is hard enough to bond thoroughly the facing mortar and the backing.

The preferable method of construction is to use a facing form like that shown by Fig. 1, fill between the facing form and the lagging with mortar, then fill behind the facing form with the backing, and finally withdraw the facing form and tamp backing and facing together.

Dry Concrete Facing.—See that the facing mixture is mixed so dry that hard tamping will not flush water to the surface. The theory of dry concrete facing is that the imprints of joints and other form marks are not readily received by it. Proportions of 1 part cement, 3 parts screenings and 3 parts fine crushed stone have proven most satisfactory.

Grout Washes.—See that holes are filled and joint marks are smoothed down before the grout wash is applied. See that the grout is applied in a very thin coat. If applied with a brush the grout should have about the consistency of ordinary whitewash. If applied with a trowel the grout should be quite stiff and applied in a very thin coat and troweled or rubbed so that only the pores are filled and no body of mortar left on the surface.

Tooling Concrete.—See that the concrete has aged sufficiently to give a good, clean tool cut; it should be at least 30 days old, and preferably 60 days old. The amount and character of the tooling will be determined by the specifications; ordinary stone cutting methods are employed.

Scrubbed Finish.—See that the scrubbing continues just long enough to remove the surface cement and to expose partially the sand or aggregate without loosening it. See that the cement particles removed by the brush are thoroughly flushed off the surface by clean water, else they will adhere in patches and form rough blotches.

The time for doing the scrubbing (when the concrete is still green but hard enough to prevent the particles of sand or stone from being easily torn from the embedding cement) will vary with the temperature, the wetness of the mixture, the activity of the cement, etc., and is a matter of judgment for each particular case. When just right a few strokes of an ordinary scrubbing brush with plenty of water will do the work.

Acid Wash Finish.—See that the acid wash is not allowed to remain too long and is thoroughly removed by washing with clean water. The acid wash should be allowed to "work" just long enough to remove the surface film of cement and to partly expose the sand grains without loosening them. Unless the surplus acid is all removed by washing it will continue to eat out the cement in places and give a pitted and blotched surface.

Gravel or Pebble Finish.—Either the scrubbing or the acid process previously described is used for securing gravel or pebble finish. See that the etching or scrubbing process is continued just long enough partly to expose the pebbles without loosening them in their cement bed. Under normal weather conditions an age of about 24 hours is about right for scrubbing; etching with acid can be done at any age.

Plaster Finish.—See that the concrete surface to be plastered is specially treated to receive the plaster coat. Plaster will not adhere well to concrete unless the surface film or skin is removed, or at least very thoroughly cleaned. The surface skin may be removed by acid washing, scrubbing or tooling. Cleaning must be done thoroughly. McCullough* gives the following directions: "Clean the surface with steam, afterwards using wire brushes and then the steam again. Wet with water, paint with neat cement and immediately follow with two coats of one to three mortar, the lower coat scratched and the top coat wood floated to a sand surface."

Painting Concrete Surfaces.—See that the concrete is perfectly dry and that its surface is prepared to receive the paint. This direction refers to painting with oil paints. Special paints are on the market for concrete which are claimed not to require dry or specially prepared surfaces. When these paints are used the inspector must follow the printed directions for applying each. The following method of preparing concrete surfaces to receive oil paints has been found successful: Wash the surface thoroughly with a 7 to 8 per cent solution of muriatic acid and follow with a good wash of clean water. After the treated surface has thoroughly dried apply the paint, using enough turpentine in the priming coat to make it almost flat and increasing the amount of oil each succeeding coat. The concrete should have thoroughly dried out before painting is attempted.

Sidewalk Construction.

Cement sidewalk construction is a task for experienced and skillful workmen which is often undertaken by unskilled and inexperienced workmen. Its inspection demands close attention to many small structural details and to the skill and honesty of the men doing the work. More sidewalks by far fail because of poor workmanship and neglect of correct principles of construction than because of poor materials.

Preparation of Foundation.—See that the excavation in cut reaches to firm soil; never permit sub-base to be laid on sod. See that soft, spongy spots, roots of shrubs, etc., are taken out and the cavities filled with firm soil. See that fills are of ample width and are thoroughly compacted. If fills are narrow they wash or cave down so that the edge of the sidewalk slab is left overhanging to tip or break down under load.

Material for Sub-Base.—See that the material used for sub-base is of such a character that it will withstand tamping without crushing to an extent that will prevent proper drainage.

Compacting Sub-base.—See that the sub-base is thoroughly compacted by tamping or rolling; see that the top is made smooth and to grade.

Wetting Sub-base.—See that the material of the sub-base is properly wetted before placing base concrete on it. If too dry it will absorb from the base the water necessary for the perfect hardening of the concrete.

Material for Forms.—See that forms are constructed of clean lumber not less than 2 ins. thick and 5 or 6 ins. wide. See that the top edges of the boards are true; they form the templets for striking the surface of the walk to grade.

Alignment and Level of Forms.—See that the alignment of the forms is exact and that their level conforms to the finished grade. The top edges of the forms serve as templets for finishing the walk and they must be true to grade.

Staking of Forms.—See that the forms are securely stacked in place; the side forms by stakes about 2 ft. apart and alternating inside and outside, the cross forms by stakes on the opposite side from that on which the concrete is being deposited.

Spacing of Forms.—See that all the forms are spaced so that the inside measurements are exactly those of the "blocks" being molded. The side forms should be marked to show where joints are to come and the cross forms should be placed so that the face against which the concrete is placed is in line with the marks indicating positions of joints.

Mixing.—See that the concrete is thoroughly mixed to as wet a consistency as will permit thorough tamping. Mixing is frequently neglected in sidewalk work and it must be watched. See that excess of water is not used to get the plasticity of mixture that should be got by thorough mixing.

Size of Batch Mixed.—See that the size of batch mixed is not greater in amount than the quantity that can be placed, tamped and surfaced before initial set has commenced. Usually all concrete should be deposited within 40 minutes from time of mixing. Retempered concrete should not be used. Any concrete left over at quitting time should be discarded.

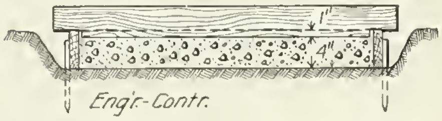

Fig. 2—Templet for Sidewalk Work.

Placing Base Concrete.—See that as nearly as practicable the exact amount of concrete is deposited which when tamped and leveled will give a surface below the finished surface (the top edges of the forms) just the depth of the surface finish. A templet of the general form shown by Fig 2 will guarantee the proper surface grade of the base.

Tamping Base.—See that the base concrete is thoroughly tamped. The concrete should be of such consistency that thorough tamping will bring just a film of water to the surface. See that the tamping is as thoroughly done at edges and corners as in the center of the slab.

Preserving Joints in Base.—See that the joints in the base between slabs are rigidly preserved.

(1). After the slab has been thoroughly tamped remove the wood cross-form and stakes so as to preserve the vertical face; tamp the concrete of the next base block against this face.

(2). Use a thin metal cross-form and have it in place until both slabs are completed, then lift it out vertically.

(3). Construct alternating slabs independently. After the first series of slabs, 1, 3, 5, etc., has been completed, construct the second series, 2, 4, 6, etc.

Expansion Joints.—See that expansion joints are constructed as specified. The usual practice is an across-walk expansion joint at approximately every 50 ft., where new walk abutts old walk (cement or stone) and, where new walk abutts on curb in place. A recommended construction is to replace one of the wooden cross-forms with a metal parting strip which is left in place until the walk is hard and is then removed and the crevice filled with paver's pitch.

Method of Placing Top Mortar.—See that the method of placing the top mortar is one which is recognized to guarantee successful work when properly carried out. One of the following methods is commonly used:

(1). Mix the top mortar quite thin, spread it regularly, and work down with a straight-edge until the surface is a true plane flush with the top edges of the forms.

(2). Mix the top mortar stiff; spread it evenly and somewhat deeper than the final surface coat, tamp it level and thoroughly into the base concrete, strike concrete with a straight-edge and bring low spots up to grade.

(3). Use a base concrete rich in cement and tamp it until the mortar rises to the top and can be leveled and smoothed by straight-edge or trowel.

Consistency of Top Mortar.—See that top mortar to be placed by floating under straight-edge is mixed wet enough to "float" readily. If too stiff it cannot be properly worked into place, and if too thin it takes too long to dry out ready for finishing and is liable to result in sandy spots. A mushy consistency about like mortar for brick work is nearly right. See that top mortar to be placed by tamping is dry enough to permit thorough tamping, the tamping should bring just a film of moisture to the top.

Time of Placing Top Mortar.—See that the top mortar is placed immediately after the base is tamped into position. If before placing the top mortar the base has begun to set or has even become dry or has had a film of dust or dirt blown over it the top mortar will not bond with the base concrete unless special precautions are taken in placing it.

Bonding Top Mortar to Hardened Base.—See that special means of securing bond are employed if for any reason the top mortar has to be placed on base concrete which has become hard. Two methods of bonding with success are:

(1). Wash the top surface of the base concrete thoroughly with water and brush off all dirt and loose material; apply to the washed surface a thin coat of cement grout well brushed in; apply top mortar in usual way before the grout has dried.

(2). Apply an acid wash, such as "Ransomite," to cut the surface film on the concrete; after the acid wash has worked, wash the concrete off with clean water until every trace of acid and dirt is removed; apply the top mortar to the wet surface in the usual way.

Placing top mortar on hardened base concrete should be permitted only in case of absolute necessity.

Marking Wearing Coat.—See that the marking of the wearing coat into blocks is directly over the block joints in the base. This rule should be rigidly enforced. See that the marking is done with a tool which cuts clear through to the base and that the joint is finished by a grooving tool, which leaves a rounded edge.

Finishing Edges of Walk.—See that the edges of the walk are finished by being rounded off to a curve about ½-in. radius. A special tool called an edger gives the best finish.

Protection From Frost.—Sidewalk work should not be done in freezing weather unless it cannot be avoided. If construction in freezing weather is unavoidable the rules given previously for protecting in freezing weather should be followed.

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*"Reinforced Concrete, A Manual of Practice."

Protection From Rain.—See that the finished walk is protected from the direct impact of rain while it is still soft. Rain falling on soft mortar washes and pits the surface. Any covering that will prevent the direct impact and wash of the rain on the green mortar is satisfactory.

Protection From Sun.—See that the walk is protected from the sun until thoroughly hardened. Too rapid drying weakens the mortar and causes hair checking. Too rapid drying by warm winds must also be guarded against.

Various methods of protecting sidewalks from too rapid drying are available. One of the best is a thick covering of sand placed directly on the top as soon as it has been finished. The sand conserves the moisture and can be wet down if more moisture is deemed necessary. Canvass, tar paper, boards, etc., are other means of covering that may be adopted.

Fractional Slabs.—See that a slab is not left partly completed at quitting time. The new concrete may not bond with the old concrete when work is resumed and a joint will result. In no case should the base be left at quitting time with the surface finish unplaced. The entire slab should be finished complete before work is stopped.

Reinforced Concrete as a Fireproof Building Material.*

BY LEONARD C. WASON.

In the last few years reinforced concrete has come into such prominence as a building material that it is attracting the attention of all who are in any way interested in building—owners, architects, engineers and insurance companies. They are asking many questions and it is the endeavor of this paper to answer a few of them, although in so doing some points will probably be covered which are already pretty well known to the insurance interests, but it is necessary to mention them in connection with a more careful study of other features which are of such recent development as to be less known at present. The writer will first endeavor to explain some of the recent developments in building construction in this material, but as "recent" is a relative term it is first necessary to explain what are now considered obsolete methods.

From the earliest use of this material, reinforcement, chiefly in the form of bars of various sections, were embedded in the concrete to take up direct tension only, concrete being required to take care of compressive stress as well as shearing stresses, both vertical and diagonal. The arrangement of beams, girders and panel has changed but little and has followed closely the arrangement common in wood and steel construction, the essential difference being in the present use of the reinforcement. Fifteen years and more ago a beam or girder was reinforced with straight bars embedded near the bottom of the member and extending for a short distance over the supports. There were no bent-up bars and no stirrups and no steel in the top of the member over the support. Such beams carried very heavy loads and are still doing good service. Some few which were overloaded showed cracks, and these, together with the cracks which have developed in a similar way in test specimens, have furnished the data for the more recent arrangement of the reinforcing metal. The next step in advance was the use of stirrups, bent either vertically or at an angle, embedded in the beams, and their ends projecting a short distance into the slab. These were embedded near the ends of the beams or girders. A little later in addition to these stirrups some of the main bars were bent diagonally upward at an angle of about 45° from about the quarter point of the span and then were carried across the top of the beam at the support and for some little distance into the adjoining span. These tied the beams together across the support and formed continuous beams, thus increasing their strength for a given weight of metal as compared with the same weight of straight bars at the bottom only, besides tying the building more thoroughly together.

The latest development which has not as yet come into general use but which ought to be encouraged is of tieing all the reinforcement rigidly together that goes into a beam or girder and so fastening it into place in the forms that it cannot possibly be moved while the concrete is being placed. When bars were placed loosely it was an easy matter to displace them by an inch in height, which makes quite a difference in the strength of the resulting combination, and the ordinary workman or even the foreman do not appreciate how important it is to set the bars exactly right. It adds a little to the expense of the steel reinforcement in place to make up the units and place them rigidly in the forms, but, on the other hand, it saves somewhat in the placing of concrete so that the resultant extra cost is comparatively small and is entirely justified. Years ago claims were made of the advantage of one type of reinforcing bar over another and also certain types of mesh reinforcement in the panel were claimed to be much better than others, with the result that when interested parties made their designs the amount of metal used was not based so much upon engineering principles as upon the commercial point of selling, and it was not uncommon to have the reinforcement stressed to nearly its elastic limit and, therefore, a structure with a very small factor of safety. Today it is well recognized that a sufficient area of cross-section of metal must be used to keep the working stress within reasonable limits, irrespective of the particular type of reinforcement used, and while deformed bars give a better bond than plain bars, either squares or rounds, and are, therefore, to be desired, nevertheless, the results obtained with the plain bars are so good that the owner is not justified in paying more than $2 or $3 a ton difference in price between deformed and plain bars.

The latest development in floor construction and one which has come to the front very quickly is the so-called mushroom system of flat floors. These are flat panels without any beams whatever supporting them, bearing on enlarged heads of the columns, the reinforcement running directly between columns and also diagonally across the panels. The expense of these floors is not greater than in beam construction of any sort and in most cases it is a little cheaper. The advantage is that less room can be used [illegible] walls, making a saving in the building. In this way a flat ceiling is obtained without the expense of a false ceiling, and from a fire protection standpoint it is desirable because it is so easily [illegible] stream of water to any part of a large room without danger of its hitting a beam or girder and being deflected to the floor before reaching the [illegible] a horizontal stream [illegible]. Also in this ceiling there are no pockets to hold heated air which would spread [illegible] through the floor above, as [illegible] in exposed panel construction with ordinary beam and girder floors. This type of floor can be used on spans as great as are ordinarily used in beam construction. The writer has built floors for 125 lbs. per sq. ft. live load on spans 20 ft. [illegible] ft. to centers of columns, using a slab 7 in. in thickness. He has also used a slab 10 in. thick on spans 21 ft. each way with a live load of 250 lbs. per sq. ft. The panel should be approximately square. If one dimension is more than 25 per cent greater than the other, economy ceases in this type of construction and it is then preferable to use beams with a panel between reinforced in one direction only.

Numerous fire tests have been made to determine both the resistance of concrete to actual fire and also the depth to which the reinforcement must be embedded to prevent its being damaged. The maximum depth of pitting observed by the writer in actual fire tests where a temperature of 1700° F. or more has been maintained for a period of five hours has been in either walls or ceilings 1 in. to 1½ in. Also by the examination of actual conflagrations such as that at Baltimore and elsewhere it has been apparent that the pre-arranged fire tests are more severe in the results shown by the structure than actual conflagrations. Therefore, if we can protect the materials against damage in a pre-arranged test, they will stand any actual service. The consensus of opinion of engineers is that there should be at least 1 in. of concrete between the nearest point of a bar to the ceiling in panels, at least 2 in. below the steel in beams and girders, and also 2 in. of concrete outside the vertical bars in columns. In designing columns it is common to figure only that area of column inside the vertical bars when hooped as carrying the load, or if hoops are omitted and but light reinforcement is used to prevent bending stresses, to add an extra inch beyond that needed to carry the load all around the outside which might be burned away without endangering the load carrying capacity of the balance of the column within. If this is burned off it can be plastered back, giving the column the same fire resisting qualities as before.

Fire underwriters are always interested in knowing whether a particular structure is properly built or not. There is but little difference in outward appearance between one of perfect construction, both in regard to size and placing of steel, size of members, etc., and one which is imperfect, and the only possible way they can know is either by inspection or by test. There is no type of construction where more painstaking care in providing for every detail is necessary than in reinforced concrete. Concrete is either good or bad. There is no half way about it and if [illegible] defects are not [illegible] before the builder is clear of his work [illegible] owner. When possible [illegible] have demonstrated their ability to erect the work [illegible] always do good work. It [illegible] preferable that the work should be [illegible] as it goes along. A [illegible] inspection is [illegible] the [illegible] of the steel [illegible] before [illegible] the concrete. The quality of the sand and [illegible] [illegible] [illegible] Well graded materials [illegible] [illegible] [illegible] workmanship to-day it is quite common to specify a mixture of 1,-2,-4, which, with thoroughly first-class workmanship, gives a stronger result than is necessary and with ordinary or careless workmanship ought to give a job which is still strong enough. Incidental to the process of construction, while the concrete is still green and much weaker than it will be with age, it is loaded frequently as heavily as it ever will be in actual service and always it is loaded sufficiently to give a fair idea of its strength. Where there is any doubt of its strength, load tests can be applied. With these safeguards, in addition to those provided by the engineer, architect or building department, the underwriters need have no fear that a building they are asked to insure is structurally weak. The question is sometimes asked, what proportion of builders now engaged in reinforced concrete work are competent? It is impossible for one who has no wide acquaintance with builders in all parts of the country to answer such a question. He can simply say that in all large cities there are a few builders whose ability has been proved beyond a doubt, and the selection of any one of them is insurance that good work will be done, and by the competition between them reasonable prices can be obtained.

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*A paper presented before the National Fire Protection Association, May [illegible], 1909, Boston, Mass.

The other types of fireproof construction which are coming into competition with reinforced concrete are structural steel encased in concrete and this when thoroughly encased from a fireproof standpoint is similar to an all concrete building; structural steel frame encased in terra cotta, and to a small extent plaster of paris and brick have been used in fireproofing steel, but not to a sufficient extent to be worthy of much comment. Thoroughly well-laid brickwork is a good protection to columns, but when cast as arches between beams it leaves the bottom flange exposed, which is a serious defect. Actual conflagrations have conclusively shown that terra cotta is not so perfect a fire protection as concrete. This is largely in the writer's opinion, due to the fact that its coefficient of expansion is high, so that it expands to such an extent that when confined between the beams it is crushed, the lower member falling and thus weakening the floor. It is also more susceptible to a combination of fire and water, being to some extent brittle and cracking when a cold stream strikes a hot surface.

Before concrete will disintegrate when exposed to fire the large amount of moisture chemically combined in the setting of the cement being 20 per cent to 25 per cent of its weight, has to be driven off by heat and then the vapor thus driven off has to be evaporated from the pores of the concrete before it becomes sufficiently hot to crumble. The slowness of evaporating this vapor is probably the cause of concrete resisting extremely high temperatures for the brief period of a few hours, while a much lower temperature, if long continued, would ultimately disintegrate it. Cement will resist 500 ° F. for an indefinite period, while a continuous temperature of over 700° F. is disastrous. The cement coating of the stones of the concrete will resist the attack of fire so long that it is of less consequence whether the stone can be damaged by the fire or not. Thus pure limestone is a most excellent aggregate and will not decompose until after the cement has, and after the cement has gone it is immaterial what aggregate is used, as the work has then failed anyway.

Bids were opened May 22, by the Bureau of Yards and Docks Navy Department, for constructing a large concrete drydock at Pearl Harbor, Hawaii.

Earth and Rock Section

Note: This Section is devoted to methods and costs of excavating earth and rock and building embankments. It will cover the grading of roads and railroads, diking and canal work, dredging, building reservoirs and earth dams, sewer and water pipe trenching, quarrying, etc.

Comments on Methods of Excavating Trenches and Ditches.

The words ditch and trench as ordinarily used by engineers and contractors are synonomous, yet there is no reason why each should not be made to mean a distinct thing, thus making it possible by the use of each word to specify a certain class of work. With this idea in view the writer has for some years used the word ditch to mean a long cut or excavation in the ground that is to remain open, and generally is excavated to hold water or carry water from one place to another. Thus we have drainage ditches, irrigation ditches, ditches for mill races and similar excavations.

On the other hand, a trench is made to mean a similar excavation, but one dug to be refilled. Thus for a ditch the sides have to be sloped or so finished that they will stand the action of water and the weather, while with trenches, it is only necessary to trim or dress the sides so as to admit of timbers being placed against the sides to prevent them from caving in. Thus, we have trenches dug, for sewers, water pipes, conduits and for many other purposes. The writer considers that an excavation is a trench even when filled in entirely with masonry or other material than that excavated from the trench. Not only does the method of digging a ditch often differ from that of excavating a trench, but costs likewise vary, without taking into consideration the back filling of the trench, which is an item of work generally included in the printed costs of excavation.

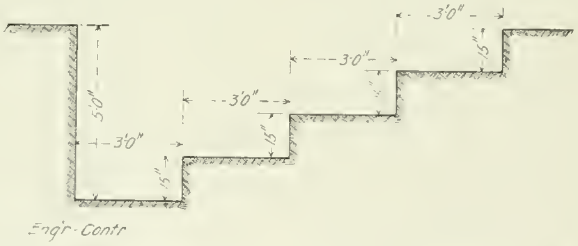


Fig. 1—Longitudinal Section of Trench Showing Method of Excavating it in Successive Steps.

Neither the method nor the cost of doing other classes of excavation is a criterion of ditch and trench digging. It is a class of work by itself. To double the depth means to much more than double the cost of excavation. An extremely narrow trench if taken to a greater depth than about three feet, means an increased cost over a trench wide enough to admit of free movements of a man engaged in digging the trench.

Individuality of men is always an important factor in carrying on work, but in ordinary excavation the placing of the individual laborer is not a difficult matter. In trench digging the individuality of the workmen counts for a great deal. Men should never be placed indiscriminately at work in a trench or ditch. After opening a section of a ditch or trench and wishing to continue the excavation, especially where there is water in the trench or ditch, the most rapid digger should be placed first in the trench, then the next best and so on down the line. This will allow the water to run towards the lowest part of the ditch or trench and one set of pumps will suffice to handle it, as well as let the timbering or shoring be carried on in its regular order. If the men were placed indiscriminately the better men would carry their sections to a greater depth quicker than the poorer workmen, causing the water to settle in their pits, thus impeding the work and increasing the cost.

A man who is slow in his movements and easily disheartened should never be placed in a treacherous ditch or trench. He will make the work cost more and will be in grave danger of being injured in case of an accident. Only alert and energetic men with great tenacity of purpose and of buoyant disposition should be used at such places. The disposition of a man counts a great deal in earth excavation done with a pick and shovel, and this is especially true of trench work. A nervous, slow and frightened man will spend nearly one-half his time watching the sides of the trench, thinking there may be a cave-in. As a rule he will watch the top of the bank instead of the bottom, where the first sifting of the dirt, which is the warning, generally commences. Men not suited to work in the ditch or trench can generally be given some employment that they can perform expeditiously and well, such work as carrying lumber for shoring, carrying pipe, shoveling earth back from the edge of the trench and attending to other necessary details.

There are several methods of placing the men at work in a ditch or trench. The most common one is to have the men spaced only a few feet apart and thus they are grouped even with a large gang so that the foreman can watch them and their work. Sometimes a certain number of men are detailed to do the picking while the rest are shoveling. This arrangement cannot be recommended, especially in narrow trenches, as the pickers often interfere with the shovelers, and in moving from place to place the pickers tramp over the loosened earth and compact it. At times a shoveler will be kept waiting for a man to do his picking. The better way is to let each man do his own picking and shoveling, unless the trench is wide enough for two men to work side by side, then, one man will loosen the earth, taking only a part of his time for this, and the rest of his time will be used up in shoveling. The men will also alternate on picking, thus spelling themselves without loss of time. This is also an advantage of a man working in a narrow trench, doing his own picking, as in changing from one kind of work to another he spells himself, which is necessary, as a man cannot keep up physical work without some seconds of rest.

The advantages claimed for this method of spacing men in a trench are that the foreman can watch the men easier than when they are scattered, and that the follow up work, such as laying pipe in a trench can be kept close to the men excavating, thus keeping the amount of open trench at a minimum. The first reason should not be given consideration, as a foreman should be kept busy and up to a high standard in his work, or he is likely to become indifferent and then allow his men to become likewise, unless he is given close supervision, which is not always possible. The second reason is often a valid one, however by reducing the number of men in the excavating gang and increasing the amount of work done by each man, this can be overcome, and brings us to a consideration of a second method of spacing men in a trench.

The trench or ditch is staked off in sections according to its width and depth, 25 or 50 ft. long. These sections should always be short enough to be finished in a day as it has a good effect on a man to complete a task in a day and not have to start on an old job the next morning. Then, too, in case of rain at night, the water can drain to the low part of the trench. By this method one man does his own picking and shoveling and he cannot interfere with another man's work. In a wide trench or ditch two men can be placed in a section to work side by side, or with a narrow trench a long section can be given to two men, the men working from each end of the section towards the center. Men working in pairs generally do better work than when working alone. The slow man will try to keep up with the faster man's pace, or if each work at the same rate, each spurs the other on to increased efforts.

In working men in sections a stake should be driven at the end of each section and numbered, as 1, 2, 3 and so on. Each section should be of the same length, or contain the same yardage. This allows of a record to be left of each man's work or if the men are working in pairs, of each team's work. Then by a record kept by the foreman or timekeeper the number of cubic yards excavated by each man is known for each day's work. This record can be kept on a form gotten up for the purpose by either the workman's name or number, thus:

RICE & COLEMAN

CONTRACTORS

Contract: John St. Sewer

Date: April 20, 1909

Size of trench: 3x6'

Workman's No.	Section No.	Cu. Yds.
61	8x19	13
62	9x18	11
63	10x17	15
64	11x20	12

Signed ______

Foreman.

By this method it will be found that men will readily dig in a trench not over 5 or 6 ft. deep from 10 to 12 cu. yds. in a 10-hour day, while by the other method, described above, men will seldom excavate over 8 or 10 cu. yds. The difference is accounted for by the fact that by the first method there is no tab kept on the individual, and one man loafing or doing indifferent work pulls down the average of the whole crew. This method shows the work done by each man and those doing indifferent work are spotted at once and can either be made to do better work by the foreman, or be discharged. Although the foreman has more ground to cover by this method, yet he does not need to devote much time to the good workers, except to see that they keep the trench the proper size and take it to the right grade, thus he can devote himself to the laggards.

This method adapts itself to setting a task for the men. Judging from the above record it would seem that 12 cu. yds. was a fair day's work for a man in this size trench, thus a task of 12 cu. yds. can be set. If a man excavates more than this yardage he should be paid a bonus for each yard excavated. Thus with wages at $1.50 per day with 12 cu. yds. excavated in 10 hrs., the cost per cu. yd. would be 12½ cts. Now, if a bonus of 8 cts. per cu. yd. is paid for every yard excavated over the task workman No. 63 earns $1.74 for his 15 cu. yds. and the cost per cu. yd. to the contractor is only 11.6 cts. This is not the only saving effected, for the foreman cost and item of general expense is also slightly reduced by an increased output. Other good results are also obtained, as the men take a greater interest in their work, and those who cannot earn a bonus soon drop out, and the contractor finds himself excavating trenches with only the most capable men and besides greater progress being made his cost is reduced. Then the foreman is relieved of much work, as with bonus-making men under him, he needs only to see that the work is done properly and keep his records, which will admit of his handling a much larger crew of men. The extra pay spurs the workman on, his mind is employed as well as his muscles, and although he works harder than under the old system yet his spirits and health are improved. This method must not be confused with piece work, for the laborer is assured of his regular wages, and when he accomplishes his task, he makes extra pay through the bonus for additional yardage.

This method of doing work can be applied to many classes of excavation work and to nearly all classes of construction.

Another method of placing men in a trench to work is to have one man excavating the first 12 or 15 ins. with another man following taking out another layer, and so on down in layers until the total depth is obtained. The advantages claimed for this method are that the men do not interfere with one another, the amount of trench kept open is reduced to a minimum, and no matter at what time a rain occurs the water will always run to the lowest point in the trench. However, this method, like the first method described, makes it difficult to obtain the best work from the men, and as the same advantages can be obtained by the second method described, it is consequently to be preferred.

Excavating a trench by layers or successive steps is to be recommended, but in using the second method of spacing men in a trench, and giving them sections to take out, this method of digging a trench by stepping it down can be adopted for each section. Fig. 1 shows a longitudinal section of a trench to be 5 ft. deep and illustrates how it can be carried down in steps. It is evident that a man working by this method always has a small breast both to pick and shovel against, except when he starts his section, where he for a short time must pick and shovel from on top. With a small breast he throws down more dirt with his pick and he also gets a much larger shovelful, as he throws the dirt out. Then, too, stepping from one step to another and casting the material out from different depths rests the man without his stopping work. With this method, if it rains the water all goes to the bottom of the trench where it can be quickly pumped out of each section either with a cellar or a diaphragm pump.

A short-handled shovel should never be used in digging trenches or ditches. The shovel should always have a long handle. The workman will do more work as he will not waste so much of his energy in bending down in the trench and then straightening up to cast the earth out of the trench. Besides this he will cast the material farther from the edge of the trench, and with a long-handled shovel the trench can be excavated much deeper without handling the material a second time. Many engineers and contractors do not seem to realize these facts as short-handled shovels are continually being used in many sections of the country. With long-handled shovels the material can often be spaded, thus saving picking. If much spading is to be done, a regular spade should be used with a long handle, except where the material being excavated is sand or sandy clay. In stiff clay the spade does as much work as the shovel, is made stronger, and it is not as hard for the man to drive into the ground as a shovel. In sand the shovel does better work as it will hold more than a spade. The shovel should be square-pointed. In fact all shovels used in trench or ditch excavation should be square pointed, except where the material is gravel or there are a large number of stones in the material or ledge rock occurs and it has to be cleaned off. Then a round-pointed shovel should be used. In ordinary material more work can be done with a square-pointed shovel and the trench can be kept better shaped. However, a round-pointed shovel is useful in cutting out a place in the bottom of a trench for the bells of pipe.

For loosening earth in a trench or ditch a pick should be used and not a mattock, as with the pick a much greater amount of material can be loosened at each blow than with a mattock. It is not possible to use the mattock in the ground for breaking from the breast and break out the dirt as with a pick, doing the work with one blow. Then the piece broken out with a mattock is a truncated pyramid, while with a pick it is a pyramid and with a larger base as well as thicker. In a stiff clay a man will loosen from 2 to 3 cu. yds. more of material in a day with a pick than with a mattock. Then with a mattock, especially if the laborer is an Italian, he will dress up the sides of the trench until they look almost as if they were plastered.

(To be continued.)

Roads and Streets Section

Note: This Section is devoted to methods and costs of road and street construction. It will cover road building in all its details, the construction of pavements, sidewalks and gutters, the testing and use of paving materials and the machinery and tools used in road building and paving.

The Theory of Economic Road and Street Location and Design.

VIII.

In the preceding seven chapters, we have discussed the value of team time, the cost per ton-mile of road maintenance, maximum grades, the cost of ascent and descent, and the value of each foot of distance saved. We come now to another application of the rule for "Value of Distance."

Circuitous vs. Direct Routes.—In locating a long road that is to traverse a region that must be served by only one main thoroughfare, the problem often arises whether a circuitous route without branches but tapping the principal productive centers, is to be preferred to a more direct route that serves these centers by lines of road branching from the main line. While this is not a common problem in road location at present, it is likely to become more so as motor car traffic develops. The proper solution of the problem is as follows.

Let *A*, *B* and *C* be three centers of production that are to be served. Either a circuitous road *A B C* may be built, or a direct road *A C* with a branch road *B D*.

Since the rule in Chapter VII for estimating the value of 1 foot of distance includes both the first cost and the capitalized value of hauling and of maintenance per foot of the road, it can be applied in solving this problem in road economics. (The rule referred to is this: To a first cost of $1 per ft. add 40 cts. for each 1,000 tons hauled annually, to get the total value of 1 ft. of distance.)

Example: There are 12,000 tons to be hauled annually from *A* to *C*, and 5,000 tons to be hauled from *B* to *C*. The distances are as follows:

A C	20,000 ft.
A B C	28,200 ft.
B C	14,100 ft.
E D C	20,000 ft.

Then, according to the rule, 1 ft. of distance for the 12,000 tons hauled from *A* is worth $1+(12×$0.40)=$5.80; while I ft. of distance for the 5,000 tons hauled from *B* is worth $1+(5×$0.40)=$3.00. Hence by the different routes we have:

(1) *A C*...$5.80×20,000=$116,000
(2) *A B C* 5.80×28,200= 163,500
(3) *B C*... 3.00×14,100= 42,300
(4) *B D C* 3.00×20,000= 60,000

By the circuitous route (*A B C*) we have (2) + (3) or $162.560 + $42,300 = $205,860. By the direct routes (*AC*) with the branch (*BD*), we have (1) + (4) or $116,000 + $60,000 = $176,000, whence it is evident that the direct route with the branch is cheaper than the circuitous route, in this case.

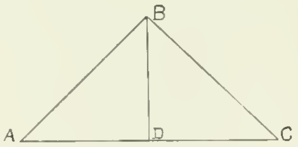
But, in this instance, *B* is so far from the main route *AC* that a still cheaper route (if no traffic is to go from *B* to *A*) is found by building only the two roads, *A C* and *B C*, for then we have (1) + (3) or $116,000+$42,300=$158,000.

This method of solution is simple of application, and it is perfectly correct where the first cost per lineal ft. of road is the same over any of the routes. If the first cost per lineal ft. differs, then consider only the capitalized value of the cost of hauling (40 cts. per ft. of distance per 1,000 tons annually), in the manner above indicated, and add thereto the actual first cost of construction by each of the routes under consideration.

Design of Economic Cross-Section.—Having considered the economies of grades and distances, the next step is to design a cross-section that shall be economic. In studying the various text books on roads we find many examples of cross-sections that have been used here, there and elsewhere, but usually accompanied by no discussion of their relative economic value. This has arisen from the fact that few authors of road books have ever built a road, and, of those that have, there are fewer still who have kept detailed costs which they have subsequently analyzed and reasoned about.

Nearly a decade ago the writer pointed out the ineconomic cross-section of the standard New York State roads, with their deep ditches having precipitous side slopes and narrow bottoms. No sort of a road machine, nor drag scraper, can be used to dig such ditches, hence the work is done entirely with pick and shovel at great unit cost, prices for such work usually being about 40 cts. per cu. yd.

The writer believes that the cross-section of a country road should usually be like that of a village street, there being gutters at the sides instead of ditches. Such a design permits the use of road machines and scrapers with which earth can be removed at a fraction of the cost of hand work. Of course there are occasionally large drainage areas that deliver their water into gutters, in which case the gutters must have their carrying capacity increased by being converted into wide, shallow ditches with gently sloping sides—a shape that permits the use of scrapers.



Deep ditches are often advocated as the means of removing all ground water below the frost level, thus preventing heaving of the road surface in freezing weather. It is rare, however, that soil is so saturated as to require any such precautions, and, where it is, tile drains should be substituted by the deep ditches.

Deep ditches, moreover, seldom remain deep. Rains wash their sides and soon fill them up in places, requiring constant expense for maintenance.

At one time the writer believed in making the road pavement thicker at the center than at the sides, but he has changed his opinion, and believes in uniform thickness. It is true that the wear is concentrated at the center, but repairs should be made frequently enough not to permit of a vertical wear of more than about an inch, in which case the center should not be more than an inch thicker than the sides.

As to the crown, or side slope, of the pavement, there may well be a difference of opinion. The writer prefers a crown, or side slope, of not less than ¾ in. to the foot on pavements less than 16 ft. wide. This sharp crown serves to keep the roadway clean, as the dust is washed off readily by rain. Although it also serves to concentrate the traffic at the center, even the slightest crown on a narrow pavement does the same.

Design of Economic Pavement.—We have now come to a part of the subject bristling with economic difficulties.

Two factors obviously have great effect upon the cost of a road pavement: (1) The width of the pavement, and (2) the thickness of the pavement. The "standards" for these are 16 ft. width and 6 ins. thickness, where macadam is used, and we see these "standards" applied with very little discrimination.

A 16 ft. pavement is a double track pavement—if we may adopt a railway term—for each vehicle is commonly said to require 8 ft. of roadway. As a matter of fact, the gauge of the wheels is usually about 5 ft. and seldom more than 6 ft., but the 8 ft. width provides for overhang of the wagon body and for slight deviations of the vehicle in traveling. Some engineers use 9 ft. as the proper width to allow for each vehicle, yet there are many double track macadam roads only 12 ft. wide, on which two ordinary vehicles can crowd by one another without the wheels going off the pavement.

The first thing to decide is whether the traffic warrants a single or a double track road. Yet how many engineers give this matter more than a modicum of thought? A railway engineer would be condemned as incompetent were he to design a new double track trunk line across the continent, to say nothing of making all its branches, or feeders, double track also. Yet where a highway engineer speaks of single track (8 ft.) pavement, even engineers, raise their eyebrows in surprise, and those who expect to use the road are thunderstruck at the public parsimony that denies them a "standard" (16 ft.) road "as good as the best." The writer has met this resistance to economic road design so often that it has ceased to surprise him, although there was a time when he marveled at the obtuseness of men in general and farmers in particular when the subject of economic road design was up for discussion.

About 16 years ago the writer located and designed some 50 miles of roads in the State of Washington, in a section that was densely timbered and where funds for road building were meagre—as is usually the case, timber or no timber. He determined to grade the roads for a double track (16 ft.) pavement, but to lay only a single track (8 ft.) pavement, and to use plank or gravel for the paved portion. Accordingly, the first road was built with plank 8 ft. wide, provided with turnouts, 16 ft. wide, at short intervals, so that two drivers of roaded vehicles could see each other, and one of them could turn out and wait for the other. The length and spacing of these turnouts were such as to add the equivalent of 1 ft. of width to the entire road. A turnout 8 ft. wide, 50 ft. long, every 400 ft., provides for two teams on a turnout, and adds the equivalent of only 1 ft. to the 8 ft. road width. Unloaded vehicles need not use the turnouts even in muddy weather, for the occasional passing of an unloaded vehicle onto the unpaved part of the road does not cut it up badly.

Incidentally it may be added that these roads were built at a cost of only $3,000 per mile, including the heaviest kind of clearing and grubbing all grading, planking and many timber trestles, log culverts, etc.

The writer believes that the great majority of country roads in America do not have traffic sufficient to justify a double track pavement, but that the traffic is rarely insufficient to justify a single track pavement without turnouts, provided the pavement is of economic design as to thickness and kind of materials used in its construction.

In our next issue it will be shown that the thickness of all pavements can be greatly decreased on nearly every kind of soil by the use of a recently developed method of compacting the soil.

The Cost of Maintaining Farm Horses and of Raising Hay and Oats in Minnesota.

The following data should be of value both to the highway engineer for estimating the cost of hauling, and to the contractor who may wish to raise feed for his horses. The data have been abstracted from bulletins Nos. 48 and 73 of the U. S. Department of Agriculture, entitled "The Cost of Producing Minnesota Farm Products." The bulletins contain very complete summaries of the results of careful investigations during the years 1902 and 1907 inclusive, covering about 70 farms in five counties of Minnesota. These bulletins mark the beginning of the scientific application of cost analysis to farming, and, so far as we know, are the only records of their kind in print.

The first step in ascertaining the cost of producing crops is to determine the cost of a horse hour and of a man hour. To do this the "route statisticians" (assisted by the farmers) kept accurate records of the number of hours that each horse was actually worked each day, as well as the number of hours worked by each man.

For the purpose of condensing the results while at the same time giving the data in considerable detail, we have selected the records of Rice county, where 21 farms of about 170 acres each were recorded. There were 5.1 work horses (not including colts or driving horses) per farm. The time of the farm owner was counted as being of no more value than of his hired men. The following is the average number of hours worked per day during the years 1902 to 1907, including the time of the farm owner:

	Week Days Man	Week Days Horse	Sunday Man
January	[illegible]	[illegible]	4.8
February	[illegible]	[illegible]	4.8
March	7.[illegible]	[illegible]	4.6
April	[illegible]	[illegible]	4.2
May	[illegible]	[illegible]	3.4
June	[illegible]	[illegible]	[illegible]
July	[illegible]	[illegible]	[illegible]
August	[illegible]	[illegible]	[illegible]
September	[illegible]	[illegible]	[illegible]
October	[illegible]	[illegible]	[illegible]
November	[illegible]	[illegible]	[illegible]
December	[illegible]	[illegible]	[illegible]
Average	[illegible]	[illegible]	[illegible]

On 20 farms in Lyon county (averaging 250 acres each) there were 8.8 work horses per farm, and on 18 farms in Norman county (averaging 210 acres each) there were 7 work horses per farm, and the average number of hours worked was as follows:

	Lyon	Norman
Per week day per man	[illegible]	[illegible]
Per week day per horse	[illegible]	[illegible]
Per Sunday per man	[illegible]	[illegible]

It would appear that the Sunday work consisted mainly in caring for the stock and milking the cows. There were about 12 milch cows per farm.

If the 3.4 hours of Sunday work represent the average daily time spent caring for the stock, etc., it would seem that this accounts in large measure for the small number of hours worked per year by each horse. Nevertheless, there is a surprising loss of horse time. According to the bulletins this is in part due to the practice on many farms of having [illegible] unnecessary horses kept [illegible] that they may be available [illegible] when the crops are being harvested.

In round numbers, we may say that each horse averaged only 1,000 hrs. worked per year, which is equivalent to 100 days of 10 hrs. each. The cost of feeding horses averaged $65 per year (1905-1907) in Rice county, $55 in Lyon county, and $43 in Norman county. The detailed cost of the feed in Rice county was as follows per horse during 1905 to 1907:

Grain for 4 winter mos.	[illegible]	[illegible]
Hay for 4 winter mos.	[illegible]	[illegible]
Grain for 8 active mos.	[illegible]	[illegible]
Hay for 8 active mos.	[illegible]	[illegible]
Total	[illegible]	$[illegible]

The prices for grain and hay were the local market prices less the cost of hauling from the farm to the market. The grain was oats, barley and corn, weighing 32, 48 and 56 lbs. per bushel, respectively. Oats at 0.85 ct. per lb. is therefore equivalent to 27½ cts. per bushel. During the years 1905 to 1907, the average farm prices of farm products throughout Minnesota were as follows: Oats, 31 cts.; barley, 45 cts.; corn, 39 cts.; hay, $6.27.

The feed per horse per day was as follows in Rice county:

	Winter season	Active season
Grain	12.1 lbs.	1[illegible].4 lbs.
Hay	15.8 lbs.	21.2 lbs.
Total	27.9 lbs.	36.6 lbs.

No account was kept of pasturage nor of any straw fed to horses. It is not clear whether the lower price (0.7 ct. per lb.) for grain in the winter season was due to feeding corn instead of oats or rye. It should be noted that the feed during the winter season cost $3.93 per horse per month, as compared with $6.18 per month during the active season. In Norman county the cost of feed was much lower, due to the practice of feeding very largely with straw in the winter months. The extent to which this was done is well shown by the following record per horse per day in Norman county:

	Winter season	Active season
Grain	[illegible]	1[illegible].4 lbs.
Hay	[illegible]	[illegible]
Total	12.[illegible] lbs.	[illegible]

The average annual cost of maintaining a horse in Rice county was estimated as follows:

	Average 1902 to 1907	For 1907
Interest on horse at 5% on the depreciated value	$[illegible]	$[illegible]
Depreciation (see below)	[illegible]	[illegible]
Harness depreciation	2.10	[illegible]
Shoeing	[illegible]	[illegible]
Feed	[illegible]	[illegible]
Labor	[illegible]	[illegible]
Miscellaneous	[illegible]	[illegible]
Total	$[illegible]	$[illegible]

The item of interest is estimated on the average depreciated value of the horse, then a horse worth $200 in its prime (4 yrs. old) has a working life of 10 to 15 years, and at the end of this time is worth [illegible], hence the interest is estimated on its average depreciated value of $[illegible].

The bulletin states that the annual depreciation of $[illegible] is [illegible] and is due to the fact that the increase in the market prices of horses has offset largely the actual depreciation. This method of accounting is [illegible], for fluctuating market values should not be allowed to affect the depreciation charged, [illegible] for the depreciation charge is really a sinking fund charge intended to restore the original investment at the end of the life of the animal. If a $150 horse has an average working life of 10 years, $15 should be charged each year for depreciation, which is $[illegible] more than the average depreciation charge above given. An item that has been entirely omitted is the cost of sheltering. The bulletins estimate this item at about $[illegible] a year for each cow, which [illegible] interest, insurance, depreciation and repairs on a barn costing $[illegible] per head housed. If we add the $[illegible] and the $8 to the $[illegible] above given, we have a total of $[illegible] as the average cost of maintaining a horse during 1902 to 1907. The corresponding cost for 1907 would be roughly $1[illegible]. Hence, on the basis of 1,000 hours worked annually, the cost of maintenance was 12 cts. per horse per hour in Rice county in 1907. Including cost of housing and a fair allowance for depreciation, there was no county where the average annual cost of maintenance fell below $100 per horse in 1907. Regarding the assumed depreciation of 10 per cent per year, the bulletin says:

> The experience of many farmers would indicate that the average working life of a farm horse is ten years.

It will be remembered that the feed was charged at its market value less the cost of hauling to market. Strictly speaking this is not correct, but the feed should be charged at its actual cost of production. This cost will next be considered, but before doing so, it is desirable to record the cost of hired farm labor in Minnesota.

The average monthly cash wages during the "crop season" (8 mos., April 1 to Nov. 30) was $26.16 in Rice county during 1905 to 1907, to which must be added the cost of board, which was $11.[illegible], making a total of $[illegible]. During the four winter months (Dec. 1 to Mar. 31), the cash wages was $15.[illegible]. This makes an average wage including board of $[illegible] per month, or [illegible] for the year. As above given, the total number of hours worked per man, including Sundays, was [illegible] hrs. per year. Hence the cost of regularly hired man labor was nearly [illegible] cts. per hr. in Rice county. The average for the three counties was 12 cts. per hr. In 1907, the cost of hired labor was $[illegible] more per month than the average of the years 1905 to 1907 in Rice county.

In addition to the regular hired men, on many farms extra men are hired and boarded by the day during the crop season, and in 1907 these men received [illegible] to [illegible] cts. per hr. including board. Unfortunately no record is kept of the amount of time these men worked in the day, so that it is impossible to state accurately what was the average wage paid to all men, including both classes.

With wages of regular hired men at 15 cts. per hr. worked, and cost of horses at 12 cts. per hr. worked, the cost of team and driver was 39 cts. per hr. in Rice county in 1907, and in no county was it less than [illegible]. It may fairly be assumed to have averaged [illegible] at least [illegible] cts. per hr. worked in 1907. If men hired by the day were employed as drivers, the cost was [illegible] cts. per hr. for team and driver. These data disagree with Prof. Ira

O. Baker's contention that team time on a farm is worth only a fraction of the ordinary rates at which teams are usually hired.

As above stated, the cost of board in Rice county averaged $14.36 per month per man in 1907, or $172 per year, or 47 cts. per day. It is not given in detail for any particular county, but the following are typical examples of the daily cost of board on two farms in 1905:

	No. 1.	No. 2.
Food	$0.181	$0.190
Fuel and light	0.041	0.027
Labor (woman at $20 per mo.)	0.171	0.120
Labor (man at about $35 per mo.)	0.019	0.012
Total	$0.412	$0.349

The higher cost on farm No. 1 is due to the fact that the average number of men boarded was only 3½ as compared with 5 on farm No. 2, thus increasing the daily cost of the labor of household work charged to each man's board.

The cost of producing various crops is given in the bulletin, but unfortunately only the average cost for the period of 1902 to 1907 is given, and not the cost for 1907 also, for wages and prices were considerably higher in 1907, and seem likely to remain so. The costs are given in terms of the acre as the unit, but, as the average amount of product per acre is also given, we can arrive at the cost per bushel or ton. Interest on the land, at 5 per cent, is properly included as a part of the cost. The following is the average cost per acre of hay in Rice county:

	Per acre.
Seed	$0.293
Mowing (first crop)	0.368
Raking (first crop)	0.178
Cocking and spreading (first crop)	0.199
Hauling to barn (first crop)	1.099
Mowing (second crop)	0.264
Raking (second crop)	0.115
Cocking and spreading (second crop)	0.150
Hauling to barn (second crop)	0.460
Machinery, interest, deprec. and repairs	0.548
Land rental ($70 at 5%)	3.500
Total	$7.178

The cost of the seed per acre was determined thus:

8 lbs. timothy at 3 cts.	$0.24
4 lbs. clover at 16 cts.	0.64
Seed for 3 yrs. at $0.293 per year	$0.88

To the above total of $7.18 per acre should be added about $1 for general expense, according to the bulletin, which would give a grand total of $8.18 per acre of hay. The average yearly production of hay (two crops) was 2.25 tons per acre in Rice county, hence the cost was $3.64 per ton. The average for three counties was 1.85 tons per acre, hence it is safe to say that the cost averaged not far from $4 per ton.

It will be noted that there is no item for plowing, the reason being that the hay seed is sown with the grain crop against which the full cost of plowing, etc., is charged. It may well be questioned whether this is correct accounting. The cost of plowing is $1.25 per acre.

The average farm price for hay in Minnesota was $6.05 per ton during the period of 1902 to 1907.

The cost of producing oats in Rice county during 1902 to 1907 averaged as follows:

	Per acre.
Seed	$0.997
Cleaning seed	0.023
Plowing (in the fall)	1.256
Dragging	0.285
Seeding	0.261
Cutting	0.401
Twine	0.335
Shocking	0.165
Stacking	0.772
Stack thrashing (labor)	0.568
Thrashing (cash cost)	0.774
Machinery, interest, deprec. and repairs	0.517
Land rental ($70 at 5%)	3.500
Total	$9.854

To this should be added about $1 for general expense, making a grand total of $10.85 per acre. The average production in Rice county was 41 bu. per acre; hence the cost was nearly 26½ cts. per bushel. The average price of oats in Minnesota was 29.2 cts. per bushel during 1902 to 1907.

The bulletin does not give the average wage paid during 1902 to 1907, but it gives enough data to enable us to say that it was about 12½ cts. per hr. worked, including board. The cost of a horse averaged about 8 cts. per hr. worked, during the same period, on the basis of depreciation assumed (which was confessedly too low) and without any allowance for cost of shelter. But, making proper allowance for depreciation and shelter, the cost of a horse was about 9 cts. per hr. worked. It is clear, therefore, that a team and driver cost more than 30 cts. per hr. worked, during the period of 1902 to 1907.

It should be noted that the farm owner's time was counted the same as an ordinary farm workman, which, as above stated, was 12½ cts. per hr. Obviously this is a questionable procedure. The farm owner is really a superintendent, even though he works with his men, and he is of a grade of intelligence that would command much higher pay than an ordinary workman. The farm owner really gets his pay in the form of "profits." If proper allowance is made for "supervision," it is evident that the costs above given will be considerably increased—probably by at least 10 per cent.

The permanent value of the data in these bulletins would be much greater were the averages made into a sort of composite picture, giving a typical average farm organization thus:

1 farm-owner.
3 regular hired men.
2 extra men (4 extra for 6 mos.).
5 work horses.
1 woman, household work.

Then the average farm "plant" should be listed, giving prices of each item, including buildings and land, cows, sheep, hogs, etc. Then the total annual product should be itemized, giving actual unit costs per bushel, pound, ton, etc.

Then should follow the unit costs per acre, and these should be tabulated so as to show the amount of work on each item, thus:

	Per acre.
Plowing: 1 team and driver, 4 hrs. at 30 cts.	$1.20
Dragging: 1 team and driver, 1½ hrs. at 30 cts.	0.45

This should be followed by the number of units produced per acre.

The information in these bulletins is excellent, but is not arranged as above indicated, and, therefore, any item of cost on any given farm cannot be compared with another except in terms of dollars and cents, which is often very misleading due to differences in rates of wages. In brief, farm costs should be recorded exactly like engineering construction costs, giving the organization of the working forces, rates of wages, prices of plant, number of hours (or days) of work at stated prices are required to perform each item of work. When recorded in this manner, accurate comparisons are readily made, and correct conclusions drawn.

By way of comparison we add some data taken from the "Encyclopedia Brittanica," under the head of Agriculture. There it is stated that during the 30 weeks of active season on the farm, each horse is fed 16 lbs. of oats and 24 lbs. of hay per day. The annual cost of maintaining a farm horse is estimated thus:

30 weeks' feed (active season) at $2.75	$ 82.50
22 weeks' feed (inactive season), clover, at $1.25	27.50
Total feed	$110.00
Interest, $200 at 5%	10.00
Depreciation, etc., $200 at 12½%	25.00
Total annual cost	$145.00

The $200 includes not only the cost of the horse, but its pro rata of farm implements. There was about 1 horse for every 30 acres of farm.

It is stated that unmanured land yields (in 1873) 16 bushels of wheat per acre, but that the application of 400 lbs. of guano per acre doubles the yield. In 1873 the average yield in England was 27 bushels of wheat (63 lbs. per bu.) per acre, an increase of 14 per cent over what it had been 80 years before. The present yield (1909) is about 32 bu. of wheat per acre in England.

In 1873 the following were regarded as being "good crops" per acre:

1 ton (2,240 lbs.) of grain plus 2 tons straw.
1 ton of beans plus 1½ tons straw.
8 tons potatoes.
17 tons beets or turnips.
35 tons cabbage.

Systematic Patching of Macadamized Roads With a Specially Designed Steam Roller and Water Tank.*

By J. S. Pickering,† M. Inst. C. E.,

While so much attention is at the present time being devoted to new methods of road surfacing in order to meet modern requirements, it is remarkable that little or no consideration is given to the simple but important operation of repair and maintenance by systematic patching. The practice now prevailing both in towns and country districts is to allow the roads to get into a general state of disrepair, and then to resurface them, or, where patching is attempted, the depressions are, as a rule, filled in with loose stone, which is left to be ground to dust or to be scattered by the fast-moving traffic, a system—or, rather, want of system—which cannot be too strongly condemned. However carefully a macadamized road is made, depressions will appear in the surface long before the road actually requires recoating, and if these defects are neglected the life of the road must necessarily be shortened. If a newly-macadamized road is kept under observation during wet weather it will be seen that inequalities of the surface, which at first appear to be small and unimportant, gradually develop with the action of the traffic and the rain water, until depressions occur which allow the water to be retained and the structure of the road to be weakened. Instead of allowing these depressions to remain and to become worse year after year, they should be systematically repaired as they appear.

When the roads are dry and hard the depressions should be neatly cut out and filled in with suitable patching metal, the smaller material removed being applied with any additional material necessary for binding purposes. After periods of rainfall the surface may not require to be loosened, and in this case the depressions should be filled with metal of a suitable gauge and covered with new binding material. Rolling and watering should then be proceeded with until the surface is uniform with the adjoining portion of the road. A patch applied in this manner may not require a shovelful of metal, but it necessitates the application of water and the use of a steam roller. In practice it is found inconvenient and costly to use the ordinary steam roller and a water cart for patching purposes, the result being that the work is seldom systematically carried out.

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*Paper read at the recent Road Conference convened by the County Councils Association of Great Britain at the Institution of Civil Engineers, April 30; May 2, 1909.

†Borough Engineer, Cheltenham, England.

The author has overcome this difficulty by the use of a specially designed steam roller and water tank combined.

The length of the roller over all is 12 ft. and the width 5 ft. The rolling wheel, which is placed at the rear, and on which the bulk of the load is concentrated, is 3 ft. 6 in. wide and 1 ft. 6 in. in diameter. A water tank of 200 gallons capacity is placed over the rolling wheel, the water being distributed behind through a perforated pipe 3 ft. wide. The distributor is divided at the center so that a spread of either 18 in. or 3 ft. may be given. The top of the water tank is formed into an iron box in which cast iron blocks are placed to enable the weight on the rolling wheel to be adjusted to the work it is required to do. The following are the weights of the machine under different conditions:

	Tons	cwt.	qrs.
Weight on rolling wheel without added weights and with water tank empty	1	7	1
Weight on rolling wheel with tank full of water but without added weights	[illegible]	[illegible]	1
Weight on rolling wheel with water tank empty	[illegible]	18	3
Weight on rolling wheel with tank full of water and added weights	6	17	[illegible]
Total weight of machine without added weights and with water tank empty	[illegible]	[illegible]	2
Total weight of machine with added weights and tank full of water	[illegible]	[illegible]	[illegible]

This roller has now been in daily use for the past nine months, and is found in every way satisfactory. It does its work quicker and better than an ordinary steam roller, and its cost has already been more than saved in economy over the old system of carrying out repairs. The staff engaged in patching consists of the roller driver and two men. The metal used for patching is drawn by the roller in a dublin cart, which holds about 2 tons. The roller travels at the rate of 6 miles an hour, and when rolling the speed is reduced to about 2 miles per hour. The water tank is filled from the fire hydrants, or when working outside the water main area the supply is taken from the nearest water course, a steam water lifter with suction hose being provided for this purpose.

The process of patching is a very simple operation, and as the same men are employed for this work they become so expert that it would be impossible a day or two after the patching is carried out to detect the position of the depressions in the road which had been thus repaired. In order to show the sensitive and easy reversing action of the engine, it may be mentioned that the roller can be made to pass over a patch 18 in. long no less than thirty times in a minute. It is surprising to find what a small quantity of water is required when it is properly applied. The two taps governing the supply to the spreader at the rear are under the control of the attendant and not of the roller driver, so that the supply to the area being rolled can be regulated without waste.

When not required for road repairs the engine may be used as a tractor or for street watering purposes, a tipping body to carry 4 tons and a water tank to hold 1,000 gallons being made interchangeable. Springs are fitted to the main axle for use when hauling or street watering. A suitable checking arrangement is provided to make the springs inoperative when rolling. This, however, has not been found necessary in practice, and the springs have a decided advantage in rendering the machine much less noisy in use than an ordinary roller.

The machine is most suitable for rolling tar macadam roads, and it has been found specially serviceable in backing up street crossings and in maintaining at a proper level the narrow strip of carriageway which is always a source of trouble where it adjoins a tramway margin. It has also been used with success in finishing off a newly resurfaced road after the heavier rollers have partially consolidated the material, the advantage being that a true and compact surface is obtained without crushing the road metal. The roller would be made still more useful if it had attached to it a single tined scarifier. The author believes that if suitable patching rollers were employed by county authorities there would be considerable improvement in the condition of the roads throughout the country, and the cost of maintenance would be appreciably reduced. The number of rollers usually provided by county authorities does not permit of the patching work being carried out systematically, and even if the rollers could be spared for this purpose from their usual work of resurfacing, they would be found too cumbersome and unwieldly to properly perform the work, and the use of horse-drawn water carts would be found too costly and impracticable. There can be no doubt about the economy of mending roads under the system advocated, to say nothing of the convenience to vehicular traffic. The author believes that the proverbial "stitch in time" is as true in its application to the repair of roads as in any other connection, but, simple and elementary as the process of patching macadamized roads may appear, the fact that although its importance is generally recognized, it is seldom carried out in a systematic and scientific manner is a sufficient reason for bringing the matter before the conference.

It should, perhaps, be mentioned that the roller described is not protected in any way by patents.

Road Treatment With Tar at Hartford, Conn.

Two years ago the roads about the Capitol grounds in the city of Hartford, Conn., were treated with tar with excellent results. The roads before the treatment were in a deplorable condition, due to the use of the automobiles speeding over them as well as to the fact that they were practically worn out and it seemed as if the only recourse to [illegible] would be to entirely rebuild them. Finally it was decided to treat the roads and take the risk as an example of what might be accomplished in the way of repair by the use of road tar. This was advised by the State Highway Commissioner, James H. MacDonald, who had had a large experience in the use of road tar in his former [illegible]. The work was conducted under a special specification written by Commissioner MacDonald and is described by Mr. Albert S. [illegible] in a recent issue of The Cornell Civil Engineer as follows:

First the macadam is cleaned of all dust and accumulations, sweeping it off with rattan brooms or a horse sweeper, until the No. 2 stones are exposed and clean. All depressions, ruts or [illegible] marks are filled with [illegible] stone [illegible] have [illegible] rolled [illegible]. After the road has been thoroughly cleaned and the depressions filled as described, the first coat of tar is applied. About 15 per cent of pitch is [illegible] and thoroughly mixed with the tar, and the mixture heated to a temperature of at least [illegible] when applied to the road. It is spread over the road and thoroughly brushed in by stiff brooms as soon as possible after leaving the heater.

After the first application has hardened and the road has absorbed all it will, a second coat of tar is applied in a similar manner to the first. This second coat is closely followed by a coating of screenings or chips (½ to ¾ in. stone) of trap rock. After depositing the stone to a uniform depth of 1 in., it should be immediately rolled a sufficient number of times to thoroughly imbed the stone in the second coat of tar.

It is especially stipulated in the specification that only pure tar shall be used; adulterations and water gas tar are barred. It is also required that this treatment shall be prosecuted only on a hot day, when the full benefit of the sun may be had. It is very important that the road shall be perfectly dry, free from dew and moisture, before any tar is placed on the surface.

The roads which have been treated under this specification have been allowed to remain during the past two years without any attention whatsoever, and it is observed that they are still practically dustless, and present a smooth surface notwithstanding the very severe winter of 1907-8 and an unusually dry summer last year. In all, the results have surpassed the best expectations.

It is not to be expected that a road repaired is fixed forever, whatever may be the method or preservative used, but it is considered that it should last two years after the first treatment. Then if another application is necessary it should stand the traffic for at least two years before it will be necessary to repair the road to a large extent again. About the Capitol grounds in Hartford there was a total of 8,774 sq. yds. treated at a total cost of $2,711, or practically $0.31 per sq. yd.

It would not be fair to consider this cost as a standard, necessarily, as the road was previously in bad condition, and will almost [illegible] would be fair [illegible] that [illegible] could be applied at a cost of less than $1,000 per mile for a [illegible] road park.

According to a recent Consular Report [illegible] consumption of [illegible] beech and pine are the only species of wood used for [illegible] and the country has been [illegible] years [illegible] ties [illegible] by the following figures for the years 1905, 1907 and 1908: 17,1[illegible] tons, [illegible] tons and [illegible] tons, respectively. [illegible] sulphate of copper, but a large proportion [illegible] treatment [illegible] companies [illegible] for [illegible] and [illegible] under the supervision of their own engineers. The [illegible] dimensions are the following: Length [illegible] width [illegible] thickness [illegible] the specifications vary somewhat with the different companies. The standard street railway tie [illegible]

Bridges, Buildings and Foundations

Note: This section is devoted to methods and costs of constructing steel and masonry bridges and buildings and of foundation work of all kinds. It will give special attention to erection plant and tools, falseworks and centers and cost data of all kinds.

Computation of a Reinforced Concrete Arch Rib with Fixed Ends for a Proposed 12th Street Bridge at Oakland, California.

BY A. W. MILLER.*

Introduction.—The assumptions and methods for designing a fixed ended arch are taken from "The University of Colorado Studies," written by Prof. Chas. Derleth, Jr., of the University of California, it being a resume of the 192-ft. main arch span of "Design No. 11 for a proposed memorial bridge across the Potomac River at Washington, D. C., the same having been designed by Prof. William H. Burr, of Columbia University, New York, during the winter of 1899-1900, and in addition all formulas and theoretical developments have been checked and compared to the corresponding subject matter in Burr's Strength of Materials, Merriman's Strength of Materials, Church's Mechanics, and Cain's Arched Ribs. (See references accompanying discussion.)

The author makes acknowledgment to Prof. Chas. Derleth, Jr., Dean of the College of Civil Engineering of the University of California, for valuable advice and criticism upon the treatment of the subject.

Data.—A reinforced concrete, arched rib with span of 155 ft., rise of 30 ft., to cross the estuary draining Lake Merritt at 12th St.; the extrados, a segment of a circle with radius of 132.5 ft.; the neutral surface of segmental elliptical form, center segment 30° radius of 131 ft., two end segments 30° each and radius of 90.5 ft.; the intrados of segmental elliptical form, the center segment with an angle of 30° radius of 129.4 ft., the two segments with 48° each and radii of 36.5 ft. Place elevation crown of roadway, 4 ft. above crown of extrados. Fill with an earth filling weight = 110 lbs. per cu. ft. Let thickness of roadway and asphalt paving = 9 ins. (.75 ft.). Weight of roadway and concrete in arch = 140 lbs. per cu. ft. Assume a live load of 100 lbs. per sq. ft. for ordinary traffic including the track of the trolley system. Assume the pressure so distributed that there is uniform load of 100 lbs. per sq. ft.

Required.—A stress sheet for dead load; and live loads covering 1., the span with tabulations appended.

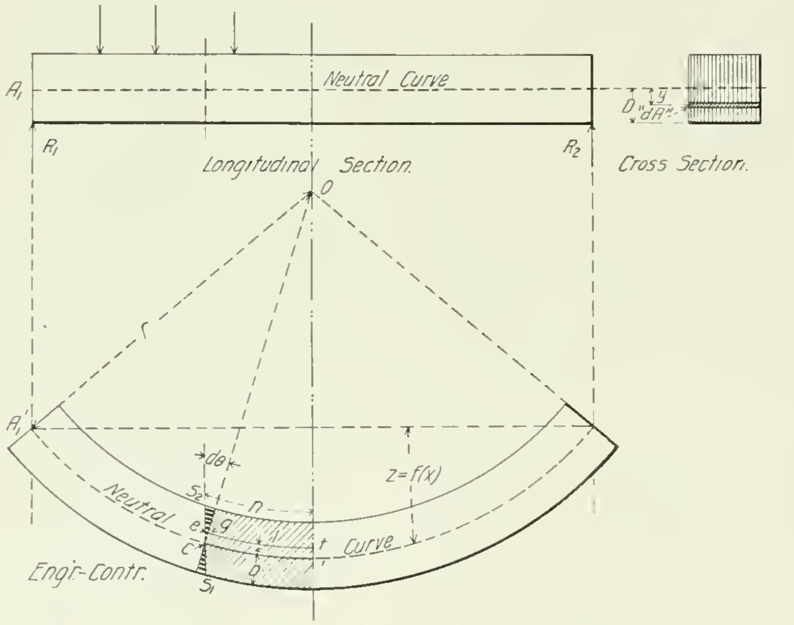

Fig. 1, 2 and 3.

Outline of the Common Theory of Flexure.

Propositions to prove: First, position of neutral surface; Second, $B\,M=\frac{K\,I}{D}$ Third, $B\,M=\frac{EI\,d^2z}{dx^2}$ or $B\,M=\frac{E\,I}{r}$

References.—Church's Mechanics, Chap III, Arts. 224 and 231; Burr's Strength of Materials, pp. 35, 37, 39; Merriman's Strength of Materials, Chap. II, Art. 20.

The Elastic or Common Theory of Flexure.—The assumptions in regard to the internal stress and strains of a simple beam will be developed first, for those of the arch depend on them. For a simple beam it is assumed that,

1st. The loads or forces are perpendicular to the longitudinal axis of the beam and the cross section is small in comparison with the length. See Figs. 1 and 3.

2d. The beam bends under the influence of the exterior forces, and the fibers are in compression on the concave side and shortened, and in tension on the convex side and lengthened. See Fig. 2.

3d. Between the tension and compression fibers is a neutral plane whose projection on the XY plane is called the neutral curve. See Fig. 1.

4th. The curvature is so slight that the external forces may be considered perpendicular to the neutral curve and in the same plane, and that the fiber stresses and strains and neutral curve may be considered parallel to the X axis.

The X axis is horizontal and the Y axis is vertical with origin at A. See Figs. 1 and 2.

5th. The stresses and strains are below the elastic limit and follow "Hooke's Law," i. e., the stresses and strains in any fiber are proportioned to its distance from the neutral surface.

There are three propositions to prove:

1st. That the neutral curve lies in the longitudinal axis of the beam.

2nd. That the internal bending moment $=\frac{KI}{D}$

3rd. Or that the internal bending moment $=\frac{EI\ (d^2z)}{(dx^2)}$

Or, that the internal bending moment $=\frac{E\,I}{r}$

Where—

K = the maximum allowable fiber stress.

I = the moment of inertia of the cross section, about the neutral axis.

E = the coefficient of elasticity.

D = the maximum distance of the fibers from the neutral surface. See Fig. 3.

z = the deflection of the beam. See Fig. 2.

r = the radius of curvature of the beam, the curve being $z=f(x)$. See Fig. 2.

First, to prove that the neutral surface lies in the longitudinal axis of the beam.

By Hooke's law, the stress in a fiber at a unit's distance (see Fig. 2) is $\frac{K}{D}=a$, a also is equal to Eu (u being the strain in a unit's fiber length at a unit's distance from the neutral surface) from $E=\frac{a}{u}$, by definition E being intensity of stress divided by the rate of strain.

In Fig. 2, $u=\frac{ge}{ct}=\frac{dn}{n}=\frac{a}{E}=d\phi \quad dn=eg$ = equal the strain in a fiber length n at a unit's distance from the neutral surface.

Since all the external forces are perpendicular to the neutral curve, the total in-

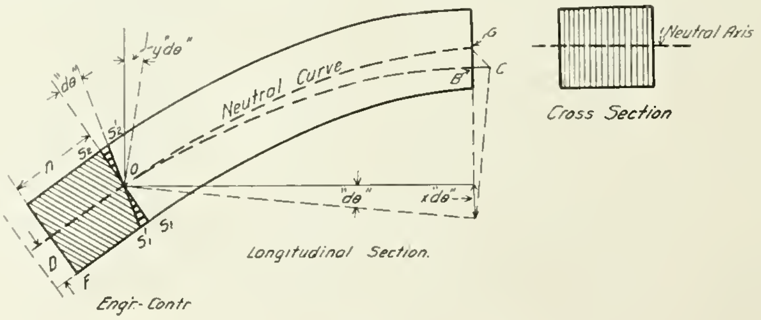

Fig. 4.

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ternal tension must balance the total internal compression.

Let dA = a strip a distance y from the neutral axis (see Fig. 3). Then the intensity of stress upon dA is equal to $\frac{Ky}{D}$ from which the

$$\text{Total compression} = \frac{K}{D}\int_{C}^{S} y\,dA$$

$$\text{Total tension} = \frac{K}{D}\int_{C}^{S_1} y\,dA$$

and these are equal. Therefore C must lie upon the horizontal axis of the beam since $dA\,y$ is the static moment and the axis about which the static moment's summation is by definition the axis of the beam. That is the tension cannot equal the compression unless $\int_{C}^{S} y\,dA = \int_{C}^{S_1} y\,dA$. The common factor $\frac{K}{D}$ canceling out.

Second, to prove that the internal bending moment equals $\frac{KI}{D}$.

The force upon the strip dA is $\frac{K}{D}dA\,y$.

Let dM equal the bending moment of this force about the Neutral Axis. Its lever arm is y. dM for $dA = \frac{K}{D}dA\,y^2$ from which total $M = \frac{K}{D}\int_{S_1}^{S} y^2\,dA = \frac{KI}{D}$ since the integral $\int dA\,y^2$ is defined as the moment of inertia $= I$.

Third, to prove that the internal bending moment equals $EI\frac{[illegible]}{D}$ equals $\frac{EI}{r}$. $BM = \frac{KI}{D} = I \times$ stress at $\frac{K}{D}$ or $BM = IEe$, from $s = Ee$.

In Fig. 2 [illegible] $= l$

$r = OC = O_1C$ = the radius of curvature. The sectors [illegible] are similar; therefore [illegible] dividing through by l, $\frac{\delta}{l} = \frac{1}{r}$ since $\frac{\Delta s}{s} = e$ the rate of strain or a fiber's plane length at a unit distance from the neutral surface from which $e = \frac{1}{r}$. Therefore by substitution $BM = \frac{IE}{r}$. Then from the calculus $r = \frac{1}{\frac{d^2y}{dx^2}}$ and making the substitution $BM = EI\frac{d^2y}{dx^2}$.

Conditions of Flexure of Arched Ribs.—1. Fixed ends cause summation of strains in any fiber to equal zero; also summation of fiber deflections to equal zero.

i. e., $\int mu = 0$. Ref. Church Art. [illegible]

$\int d\alpha = 0$ [illegible] Fig. 4.

Total horizontal deflection equal zero.

Total vertical deflection equal zero.

II. Proof that $M = Hy$.

III. The Assumed Conditions are that $\frac{HX}{EI}$ equals a constant.

$\int x = 0$ Ref. Church Arts. 373-374

$\int xy = 0$ Cain 50, Fig. 10, 11, 12.

$\int x_y = 0$ Barr 230-238.

IV. Relation between Arch intercepts (x) and Funicular Frame intercepts (m).

i. e. $\int x = \int m = 0$. Ref. Barr [illegible]

$\int xy = \int$ [illegible]

$\int xy = \int$ [illegible]

V. Method of obtaining true Funicular frame from trial Funicular frame.

First: making $\int x = \int dx$ by the lever arm principle. Reference Church Art. 377, Cain 48-51, Art. 22.

Second: $\int xy$ and $\int dy$ are inversely proportional to the trial and true pole distances of the funicular frames. Reference Barr 245, 215; Church Art. 381.

VI. An alternate method of obtaining the trial funicular frame. [illegible] Cain, p. 46.

Derivation of Formula of Arched Ribs.—The ends of an arch being fixed, the summation of the strains in any fiber a given distance from the neutral surface equal 0.

Expressed as follows:

$$\int_{K}^{K_1} mu = 0$$

Where

m = lengths into which fiber is divided, equidistant from neutral surface.

u = strain of unit length at unit's distance from the neutral surface.

K_1 and K are the abutments or limits of arch.

By the Common Theory of Flexure $u = \frac{M}{EI} = u$

Where

M = the external bending moment to which the arch is subjected.

E = coefficient of elasticity.

I = the moment of inertia of cross section.

[illegible] the deformation due to internal bending moment. (Consider length at the section $S-S_1$. See Fig. 4.) The bending moment, $M = \frac{KI}{D}$, from which $K = \frac{MD}{I}$.

K also $= \frac{E(S-S_1)}{[illegible]} = \frac{E\,D\,u}{[illegible]}$ [illegible]

1. $d\alpha = \frac{Mu}{EI}$ and for whole length of member total angular deflection equals $\int d\alpha = \int\frac{Mu}{EI}$.

2. The horizontal linear deflection $BC = d\alpha\,y = \frac{My\,u}{EI}$. See Fig. 4 for the bending in the lengthwise. For the bending in all the fibers throughout the arch added together:

Total horizontal linear deflection

$$\Sigma h = \int\frac{Myu}{EI} = 0$$

3. The vertical linear deflection $EB = d\alpha\,x = \frac{Mxu}{EI}$. See Fig. 4.

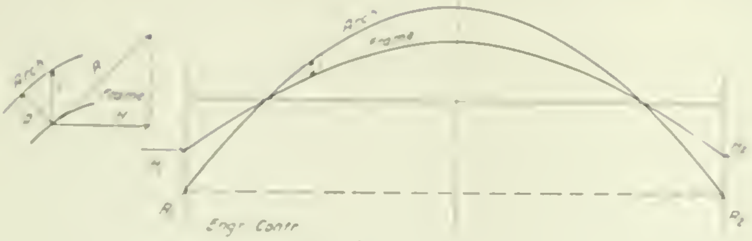
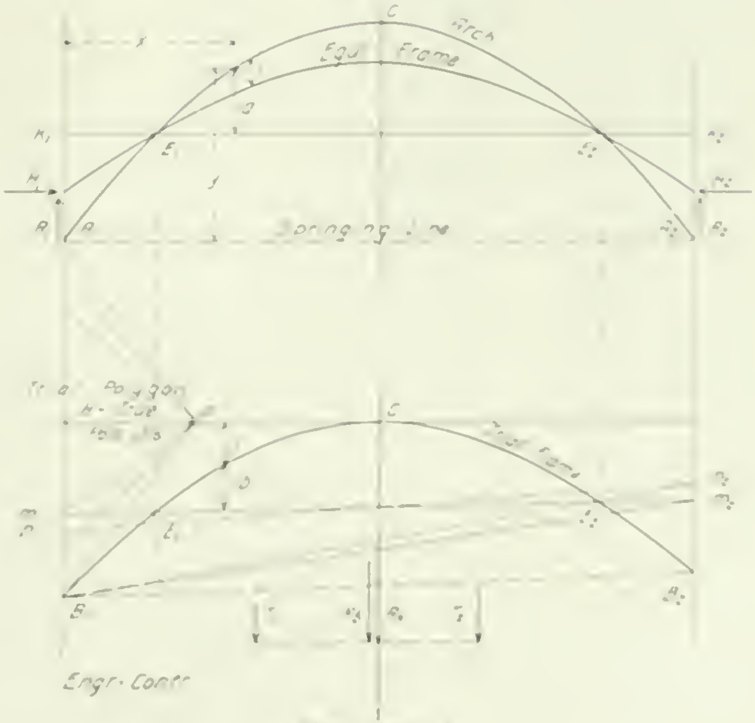


Fig. 5.



Figs. 6 and 8.

Total vertical linear deflection

$$Dv=\int\frac{Mxn}{EI}=0$$

The n's should be so chosen that $\frac{n}{I}=$ a constant, $M=Hi$, where $H=$ pole distance for the true furnicular polygon $=$ horizontal thrust and i is the bending moment intercept for the fixed ended arch, i. e., the distance from the arch to the true funicular frame. See Fig. 5.

Proof that $M=Hi$.

For any given loading upon the arch there is a true funicular or equilibrium frame. This frame gives the position and direction of the resultant of the external forces at any section, as S_1-S_2, upon the arch. The magnitude of this resultant can be found from the ray in the funicular or equilibrium polygon, which is parallel to the line tangent to the frame at the section.

Let R be the resultant at S_1 and H its horizontal compound $=$ pole distance.

Let $p=$ the distance of R from section and i the intercept. See Fig. 5. By similar triangles $Rp=Hi$ Q. E. D.

Then in the expression for moment, the

Space	n_1	n_2	n_3	n_4	n_5	n_6	n_7	n_8	n_9	n_{10}	n_{11}	n_{12}	n_{13}	n_{14}
Length = n	25.30 ft	10.50 ft	5.40 ft	4.40	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
Horiz Proj	13.70 "	9.25 "	5.00	4.00	3.90	3.90	3.90	3.95	3.35	3.35	4.00	4.00	4.00	4.00
Depth = D	5.60 "	4.20 "	3.30	3.10	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Dead Load	77,000 lbs	23,000 lbs	10,300	7,800	6,400	5,350	5,500	5,100	4,800	4550	4,350	4150	4,050	3,950
Live Load	2,000 "	900 "	500	400	400	400	400	400	400	400	400	400	400	400
Total Load	79,000 "	23900	10800	8200	6800	6350	5900	5500	5200	4950	4750	4550	4450	4350
Σ Loads from R_2	341,700 "	262,700	238800	228,000	219800	213,000	206,650	200,750	195,250	190,050	185,100	180,350	175,700	171,250
Σ Loads from C	174,700 "	95,700	71,600	61,000	52,800	46,000	39,650	33,750	28,250	23,050	19,100	13,350	8,800	4,350
M Sec to Center	R. 4,947,000 322,000	1,847,000	1,342,000	1,167,000	857,000	677,000	522,000	394,000	272,000	188,000	116,000	52,600	17,400	-
Intercept J	R. 24.73 16.13	3.23	6.71	5.38	4.28	3.38	2.61	1.95	1.32	0.94	0.58	0.26	0.09	-

Space	n_{15}	n_{16}	n_{17}	n_{18}	n_{19}	n_{20}	n_{21}	n_{22}	n_{23}	n_{24}	n_{25}	n_{26}	n_{27}	n_{28}
Length = n	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.40	5.40	10.50	25.30
Horiz Proj	4.00	4.00	4.00	4.00	3.95	3.95	3.95	3.90	3.90	3.90	4.00	5.00	9.25	19.70
Depth = D	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.10	3.30	4.20	5.60
Dead Load	3,950	4,050	4150	4350	4550	4800	5,100	5500	5,950	6,400	7800	10,300	23,000	77,000
Live Load	- -	- -			-			-	-	- - -	-	- -	-	-
Total Load	3950	4050	4150	4350	4550	4800	5,100	5500	5950	6,400	7800	10,300	23,000	77,000
Σ Loads from R_2	166,900	162,950	158,900	154,750	150,400	145,850	141,050	135,950	130,450	124,500	118,100	110,300	100,000	77,000
Σ Loads from C	3,950	8,000	12150	16,500	21,050	25850	30,950	36,450	42,400	48,800	56,600	67,400	90,400	167,400
M Sec to Center	-	15,800	47,800	96,400	164,900	247,900	343,900	470,300	612,900	777,900	971,000	1,226,000	1,706,000	3,006,000 R_1 4,646,000
Intercept J	-	0.08	0.23	0.48	0.82	1.24	1.75	2.35	3.06	3.89	4.85	6.13	8.58	15.03 R_2 23.23

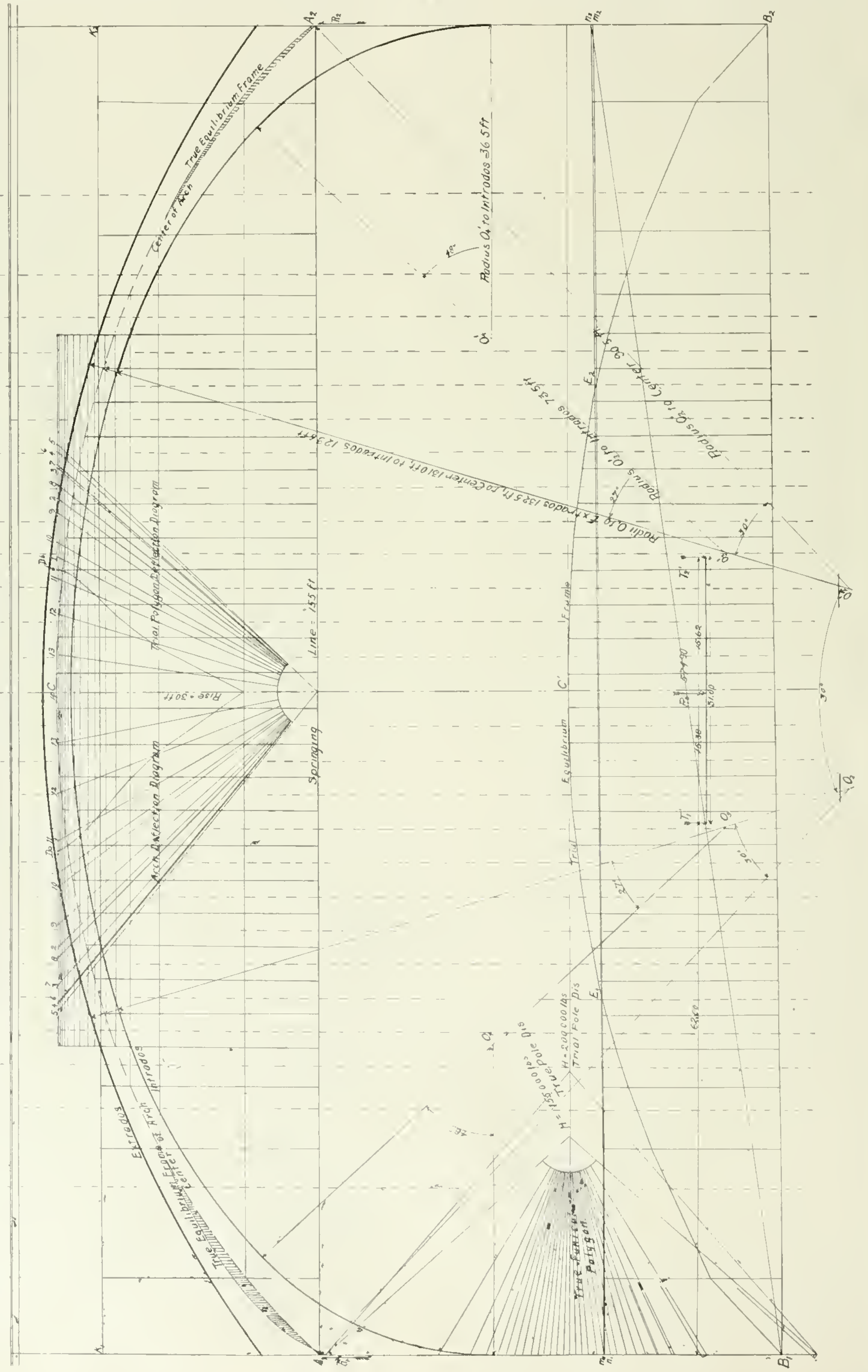

True Equilibrium Frame
Center of Arch
Extrados
Introdos
Arch Deflection Diagram
Trial Polygon Deflection Diagram
Rise = 30 ft
Springing
Line = 155 ft
Radius O₁' to Introdos 36.5 ft
Radii O₁ to Extrados 132.5 ft, to Center 131 ft, to Introdos 123.5 ft
Radius O₂' to Introdos 73.5 ft
Radius O₂ to Center 90.5 ft
Trial Equilibrium Frame
H = 156,000 lbs True Pole Dis
H = 200,000 lbs Trial Pole Dis
True Funicular Polygon
A₁
A₂
B₁
B₂
C
C'
E₁
E₂
O₁
O₂
O₁'
O₂'
T₁
T₂
R₁
R₂
27°
30°
75.38
51.00
15.62
57.90
62.60

Fig. 7.

pole distance is constant and i, the intercept between the arch and true frame, is the only variable.

Therefore $\frac{Hn}{EI}\int_{K_1}^{K_2} i = 0$ [illegible]

For any given n vertical deflection = $(d\phi)x$ and horizontal deflection = $(d\phi)y$,

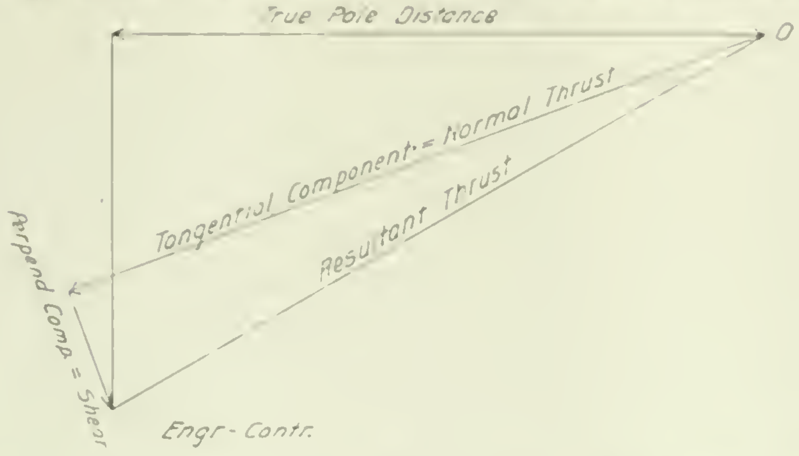


Fig. 9.

the x's and y's being measured from axes through the [illegible], [illegible] and the total sum of their deflections = 0.

Therefore:

$$\int_{K_1}^{K_2}(d\phi)x = 0 = \frac{Hn}{EI}\int_{K_1}^{K_2} ix \text{ and}$$

$$\int_{K_1}^{K_2}(d\phi)y = 0 = \frac{Hn}{EI}\int_{K_1}^{K_2} iy$$

The required conditions are:

1. $\frac{Hn}{EI}$ = a constant
2. $\int_{K_1}^{K_2} i = 0$,
3. $\int_{K_1}^{K_2} ix = 0$, and
4. $\int_{K_1}^{K_2} iy = 0$.

Note.—There are [illegible] $\frac{Hn}{EI}$ a constant [illegible] $\frac{H}{E}$ [illegible] must then be [illegible]. The method is to make both n and I vary [illegible] the angle of inclination of the arch. This makes the horizontal projections of the [illegible] equal.

To satisfy these four equations the true equilibrium polygon and frame must be found, and a closing line common to the frame and the rib. The pole distance of the true equilibrium polygon equals the horizontal thrust and the common closing line [illegible] the points where the frame and arch are coincident.

Let m be the intercepts between the closing line $K_1 K_2$ and the [illegible] and y be the intercepts on the true equilibrium frame [illegible] and the closing line $M M_1$. See Fig. 7.

1. Then [illegible] $\int$ [illegible] $\int$ [illegible] $\int$ [illegible]

$\int$ [illegible] $\int$ [illegible]

2. $\int$ [illegible] $\int$ [illegible] $\int$ [illegible]

3. $\int$ [illegible] $\int$ [illegible] $\int$ [illegible]

Note. The x's are measured from the [illegible] and the y's from the [illegible] line of the arch. See Fig. [illegible]

Let the trial frame be $B B_1 B_2 B_3$ [illegible]. See Fig. 7. It is necessary to find a closing line $m m_1$ so that the sum of the intercepts will equal zero and the sum of their products [illegible] also equal to zero. First get the average value for the intercepts between the line $B B_2$ and the trial frame and draw the line $n n_1$ at this [illegible] above the line B_1B_2 and parallel to it. This makes the sum of [illegible] equal zero.

To satisfy the condition that [illegible] times [illegible] equals zero, the resultant R of the intercepts between $B B_2$ and the trial frame must be equal and coincident with the resultant Rn of the intercept between the line $B B_2$ and $n n$.

Rn is the center of the [illegible]. A new line $m_1 m_2$ must be drawn such that R would be equal to and coincident with [illegible] R [illegible] found by the principle of moments, using B as an origin. See Fig. 7.

Divide the rectangle $B n_1 n_2 B_2$ into the triangles $B n n_1$ and $B n_2 B_2$.

Let T be the sum of the intercepts of triangle $B n n_1$, also T_2 for triangle $B n_2 B_2$.

Then $T + T_2 = Rn$

T_1 and T_2 are symmetrical about the center vertical axis.

R will then be divided by the principle [illegible] the [illegible] T_1 [illegible] and T_2 [illegible] which will [illegible] the [illegible] [illegible] T_1 and T_2 [illegible]

Thus:

[illegible]

Hence the [illegible]

The line X_1X_2 should be drawn [illegible]. See Fig. 6. [illegible]

[illegible] must equal the same [illegible], and if they are not equal they are inversely proportional to the ratio of the trial pole distance to the true pole distance of the [illegible]. [illegible] there are [illegible] intercepts [illegible] it is easy to [illegible] the trial pole distance for the true equilibrium frame, as illustrated in the "[illegible] of the [illegible] Bridge" of this article.

A good [illegible] for [illegible] Frame [illegible] as developed [illegible] is as follows:

If the moments of the loads between the center and a given section [illegible] are found, the same [illegible] frame as in the ordinary [illegible] will be drawn, but with the [illegible] frame instead of below, it being a [illegible].

In the figure (see Fig. 7) the horizontal thrust H [illegible] is assumed [illegible] the loads [illegible] off below and [illegible].

By the theory of the [illegible] frame the moments of the loads between [illegible] about the section [illegible] the intercept [illegible] multiplied by the pole distance H, [illegible] the intercept [illegible] frame.

[illegible] draw the frame [illegible] accurately, [illegible] the moments of the loads between each section and the center about the section, then divide the moments by an assumed pole distance, and the true lengths of the intercepts [illegible]. See Fig. 8.

This is much more accurate than the old Graphic method. The calculations of the moments for the successive sections, passing from the center to the [illegible], may be made comparatively easy.

The sections should be taken under the loads. The increase in the moment from one section to another equals the sum of the loads included by the distance between the sections. [illegible] the sum of the loads from the center [illegible] the distance between the loads and the [illegible] times the distance to the next load. The

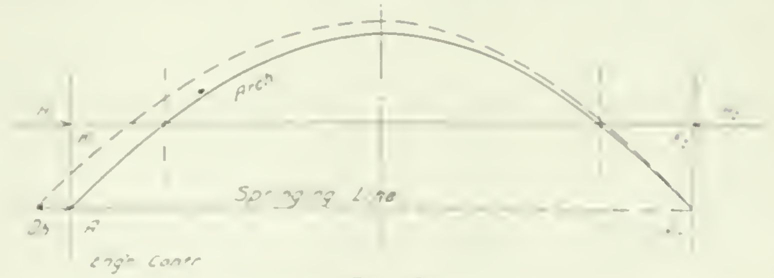


Fig. 10.

[illegible] of the last section.

Some authors [illegible] the [illegible] of measuring the intercepts at the ends of the sections instead of under the loads, [illegible]

[illegible]

[illegible]

taken at the crown = 4 ft. with $d = 3$ ft. See Fig. 7, Table I.

TABLE 1.

No.	Length.	Depth.	(n/d^3).
1	25.20	5.60	.148
2	10.50	4.20	.148
3	5.40	3.30	.148
4	4.40	3.10	.148
5	4.00	3.00	.148
6	4.00	3.00	.148
7	4.00	3.00	.148
8	4.00	3.00	.148
9	4.00	3.00	.148
10	4.00	3.00	.148
11	4.00	3.00	.148
12	4.00	3.00	.148
13	4.00	3.00	.148
14	4.00	3.00	.148

The loads for each subdivision or *n* should next be calculated. The equivalent side elevation area for each *n* must be obtained for both the earth fill and concrete. See Table 1, Fig. 7.

No.	Horiz. proj.	Depth earth.	Depth roadway.	Vertical depth.	Equiv. concrete.
1	19.70	28.50	.75	12.25	13.00
2	9.25	17.00	.75	5.25	6.00
3	5.00	13.00	.75	4.00	4.75
4	4.00	11.50	.75	3.50	4.25
5	3.90	10.00	.75	3.20	3.95
6	3.90	9.00	.75	3.10	3.85
7	3.90	8.00	.75	3.10	3.85
8	3.95	7.00	.75	3.05	3.80
9	3.95	6.25	.75	3.05	3.80
10	3.95	5.50	.75	3.05	3.80
11	4.00	5.00	.75	3.05	3.80
12	4.00	4.70	.75	3.05	3.80
13	4.00	4.40	.75	3.00	3.75
14	4.00	4.20	.75	3.00	3.75

Total load is by addition. See Table I, Fig. 7.

No.	Dead load.	Live load.	Total load.	Sum of total loads.
1	77,000	2,000	79,000	79,000
2	23,000	900	23,900	102,900
3	10,300	500	10,800	113,700
4	7,800	400	8,200	121,900
5	6,400	400	6,800	128,700
6	5,950	400	6,350	135,050
7	5,500	400	5,950	140,950
8	5,100	400	5,500	146,450
9	4,800	400	5,200	157,650
10	4,550	400	4,950	156,600
11	4,350	400	4,750	161,350
12	4,150	400	4,550	165,900
13	4,050	400	4,450	170,350
14	4,950	400	4,350	174,700
	166,900	7,800	174,700 7,800	166,900
Check			166,900	
Total				341,600

FIG. 7, TABLE I, OF LOADS, Σ OF LOADS AND DISTANCES BETWEEN CENTERS—ONE-HALF LIVE LOAD.

No.	Loads.	Σ of loads from center	Hor. proj.	Dis. bt. centers	(Σ of loads) dis. bt. centers
14	4350	4350	4.00	2.00	
13	4450	8800	4.00	4.00	17400
12	4550	13350	4.00	4.00	35200
11	4750	18160	4.00	4.00	53400
10	4950	23050	3.95	3.98	72000
9	5200	28250	3.95	3.95	91000
8	5500	33750	3.95	3.95	111000
7	5900	39650	3.90	3.92	132000
6	6350	46000	3.90	3.90	155000
5	6800	53800	3.90	3.90	180000
4	8200	61000	4.00	3.95	210000
3	10800	71800	5.00	4.50	275000
2	23900	95700	9.25	7.12	505000
1	79000	174700	19.70	14.48	1380000
R1				9.85	1720000

FIG. 7, TABLE I, OF LOADS, Σ OF LOADS AND DISTANCES BETWEEN CENTERS—ONE-HALF LIVE LOAD.

No.	Loads.	Σ of loads center	Hor. proj	Dis. bt. centers	(Σ of loads) dis. bt. centers
15	3950	3950	4.00	2.00	
16	4050	8000	4.00	4.00	15800
17	4150	12150	4.00	4.00	32000
17	4350	16500	4.00	4.00	48600
19	4550	21050	3.95	3.98	65500
20	4800	35850	3.95	3.95	83000
21	5100	30950	3.95	3.95	102000
22	5500	36450	3.90	3.92	121000
23	5950	42400	3.90	3.90	142000
24	6400	48800	3.90	3.90	165000
25	7800	56600	4.00	3.95	193000
26	10800	67400	5.00	4.50	255000
27	23000	90400	9.25	7.12	480000
28	77000	167400	19.70	14.48	1300000
R2				9.85	1640000

FIG. 7, TABLE I. OF MOMENTS OF LOADS FROM SECTION TO CENTER—ONE-HALF LIVE LOAD. POLE DISTANCES=200,000 POUNDS.

Sec.	Mom.	J.	Sec.	Mom.	J.
14	.....	....	..	.....	....
13	17400	.09	16	15800	.08
12	52600	.26	17	47800	.23
11	116000	.58	18	96400	.48
10	188000	.94	19	164900	.32
9	279000	1.35	20	247900	1.24
8	390000	1.95	21	349900	1.75
7	522000	2.61	22	470900	2.35
6	677000	3.38	23	612900	3.06
5	857000	4.28	24	777900	3.89
4	1067000	5.38	25	971000	4.85
3	1342000	6.71	26	1226000	6.13
2	1847000	9.23	27	1706000	8.53
1	3227000	16.13	28	3006000	13.03
R	4947000	24.73	R2	4646000	23.23

Figure 7 is the stress sheet for the one-half live load. Over the arch itself Table I is drawn, line one contains the numbers of the spaces into which the arch is divided, line two their true lengths, line three their horizontal projections, line four their average vertical depths, line five the dead loads, line six the live loads, line seven the total loads, line eight the sum of the loads from R_2, line nine the sum of the loads from the center each way, line ten the moments of the loads, between the section and the center, about the section as an origin, and line eleven the intercept *J* for location of the trial funicular frame, using a trial pole distance of 200,000 lbs.

Let the trial frame be $B_1E_1C^1E_2B_2$. It is necessary to find a closing line m_1m_2 so that the sum of the intercepts *(ib)* equal zero, and the sum of their products *(ib)* times *(x)* is also equal to zero. First get the average value for the intercepts between the line B_1B_2 and the trial frame and draw the line n_1n_2 at this height above the line B_1B_2 and parallel to it. The work can be greatly facilitated by making a table for stress analysis. This is Table II, which is given further along in this article. Column 1 gives the section of the arch, column 2 the intercepts between the springing line $A_1—A_2$ and the arch, column 3, the intercepts between the line B_1B_2 and the trial frame. The value for B_1n_1 and B_2n_2 is found by dividing the sum of column 3 by 28, and is equal to 20.53.

To satisfy the condition that *(ib)* times *(x)* equals zero, the resultant *Rb* of the intercepts between B_1B_1 and the trial frame must be equal and coincident with the resultant *Rn* of the intercept between the line B_1B_2 and n_1n_2.

Rn is at the center of the arch. *Rb* is found by the principle of moments using R_1 as an origin. Column 4 gives the lever arms, column 5 the moments. From column 3. *Rb* equals 574.90 and its position is found by dividing the sum of column 5 by the sum of column 3, and is 77.38 ft. from R_1 or the left abutment.

Divide the rectangle $B_1n_1n_2B_2$ into the triangles $B_1n_1n_2$ and $B_1n_2B_2$

Let T_1 be the sum of the intercepts of triangle $B_1n_1n_2 = 287.45$; also T_2 for triangle $B_1n_2B_2$.

Then $T_1 + T_2 = R = 574.90$. See column 3.

T_1 and T_2 are symmetrical about the center vertical axis. They are at a distance of 62 ft. from the abuts determined by the principle of moments obtained by dividing the sum of column 7 by the sum of column 6.

Rb will then be divided by the principle of the lever into its true components, T^1_1 and T^1_2, and the resultants of triangles $m_1m_2B_1$ and $B_1n_2B_2$, which will have the same ratio to T_1 and T_2 as B_1M_1 and B_2M_2 have to B_1n_1 and B_2n_2.

The span T_2^1 and $T_2^1 = 31$ ft.

$T_1^1 = 15.38$ ft. from *Rb* and $T_2^1 = 15.62$ ft. from *Rb*.

$$\text{Then } T_1^1 = \frac{574.90\times 15.62}{31} \text{ and } T_2^1 + \frac{574.90\times 15.38}{31}$$

$$B_1 m_1 - \frac{41.06\times 15.62}{31} = 20.63 \text{ and } B_2 m_2 - \frac{41.06\times 15.38}{31} = 30.43.$$

Note $41.06 = B_1n_1 + B_2n_2$.

Column 8 gives the intercepts of the trapezoid $m_1m_2B_1B_2$, and subtracting these from column 3, the values of column 9 are obtained, giving the true values *(ib)* on the trial frame such that the sum of *(ib)* equals zero and the sum *(ib)* times *(x)* equals zero.

The line K_1K_2 should be drawn on the arch as the average of its intercepts which was 25.53 above the springing line $A_1 — A_2$ column 10 is obtained by subtracting the value 25.33 from the intercepts in column 2 and gives the value of *(ia)* such that the sum *(ia)* equals zero and the sum *(ia)* times *(x)* equals zero.

If the sum *(iy)* equals zero, then the sum *(ia)* times *(y)* must equal the sum *(ib)* times *(y)*, and if they are not equal they are inversely proportional to the ratio of the trial pole distance to the true pole distance of the funicular frame. Since there are two intercepts for each *(y)* their sums by pairs are obtained in the upper halves of columns 11 and 12, and the corresponding values of *(ia)* times *(y)* and *(ib)* times *(y)* are given in the lower halves of the same column. The *Y's* are found in column 2. The ratio of the sum of the *(iby)* to the sum of the *(iay)* is 0.78. These values are checked by the deflection polygons on Fig. 7. The deflection polygons are cantilever funicular frames with the crown of the arch as the origin, the intercepts *ia* and *ib* as forces. The intercept *CDa* (see Fig. 7) is the moment intercept for the quantities *(ia)* *(r—y)*, about the point in the crown of the arch, this being a cantilever bending moment. *(r)* = the rise of the arch. *CDb* is the corresponding value for *(ib)* *(r—y)*. These are called deflection polygon intercepts and have the same ratio as the sum *iay* and the sum *iby* and equal 0.78. The true pole distance therefore is 200,000 lbs. times 0.78, 155,000 lbs. The true equilibrium frame intercepts then become 1.28 times the trial intercepts *(ib)* and are shown in column 13. The true bending moments intercepts are then found by subtracting the *(ia)* intercepts from the true *(ib)* intercepts, i. e., the value in column 10 from those in column 13. These last values are given in column 14 and the external bending moments in feet pounds are given in column 15.

As a check the value of column 14, from *n* to *n*, should equal zero. In the problem the intercepts are so small that they cannot be read or calculated accurately. The sum of the positive values equals 2.04 and the negative value 2.29, a difference of 25. A change of .01 ft. on each intercept would change the value. Hence the work is close enough for practical purposes.

Drawing the true equilibrium frame upon the arch, the intercepts will have appreciable values at the abutments, but in the central portion the frame will so nearly coincide with the center of the arch that it has been omitted on Fig. 7.

The rays of the equilibrium or funicular polygon are drawn from *H*, the true pole distance, and the resultant thrusts as tabulated in column 16 are found. The normal thrusts and shears at any section are found by resolving the resultant thrusts into component, tangent and perpendicular to the center line of the arch at the point. See Fig. 8 for illustration and True Funicular Polygon, Fig. 7 for actual work. The normal thrusts are found in column 17 and the shears in column 18, though with the exception of the sections near the abutments the shears approximate zero. The normal thrusts approximate the resultant thrusts at all points.

The vertical intercepts between the true frame and the rib are proportional to the bending moments, and this intercept times the pole distance equals the moment acting upon the arched rib. See column 15.

In considering the effect of reinforcing,

$$\mu = \frac{Mn}{E_c I_c + eI_s} \quad \text{Therefore} \quad \sum \frac{Hn}{E_c I_c + eI_s} = 0$$

$$\sum \frac{Hnx}{E_c I_c + eI_s} = 0 \qquad \sum \frac{Hny}{E_c I_c + eI_s} = 0$$

H = horizontal thrust or pole distance

E_c = coefficient of elasticity of concrete = 2,500,000 lbs. per sq. in.

E_s = coefficient of elasticity of steel = 30,000,000 lbs. per square inch.

I_c = moment of inertia of concrete

I_s = moment of inertia of steel

A_c = area of concrete

A_s = area of steel

e = E_s divided by E_c = 12

T = Normal thrust. See column 17

M = external bending moment

d = extreme distance of concrete from neutral surface

d_1 = extreme distance of steel from neutral surface

s_c = extreme stress in concrete

s_s = extreme stress in steel

Note.—These T's are not the points on the stress sheet.

The steel should be less than 1 per cent of the area of the cross section and it can be neglected in making approximpate calculations.

In making the calculations it is more convenient to take 1/12 of T and a vertical section of the arch 1 in. wide. Then I becomes equal to $d^3/12$. See column 20. Column 18 gives d in inches and column 19 d^3.

This also makes the bending moment in foot pounds in column 15, the bending in inch pounds for a section 1 in. wide.

All dimensions being reduced to inches, the stresses in the extreme fibers of the concrete without steel are found by the formula

$$S_c = \frac{T}{A_c} + \frac{dM}{I_c} \quad \text{See Column 22.}$$

If steel is used the maximum stresses in the extreme fibers of the steel and concrete are found by the formulas

$$S_c = \frac{T}{A_c + eA_s} + \frac{dM}{I_c + eI_s} \quad \text{See Column 23.}$$

$$S_s = \frac{eT}{A_c + eA_s} + \frac{ed_1 M}{I_c + eI_s} \quad \text{See Column 24.}$$

Analysis of Thermal Stresses.—The expansion and contraction due to variations in temperature induce internal stresses. In fact any change of form does likewise, as the contraction due to loads. The ends of the rib remain fixed, the expansion due to temperature changes causes deflections in the rib, which induce the thrusts of the reaction and bending moments.

The stresses and bending moments by thermal variations are those which would be caused by a horizontal force of proper magnitude and having the proper line of action, i. e., the ones induced by thermal variations. See Fig. 10.

The problem becomes to find the magnitude of the induced horizontal thrust and its line of action.

If it is of value [illegible] divide it into the weighted lengths "[illegible]" such that

$$\frac{s}{EI} = \text{a constant.}$$

Since the arch is symmetrical in reference to both the x and y axis through the vertex, $K K_1$ the line that [illegible] the condition Σ[illegible] = 0 is located by taking the aver-

TABLE II. FOR STRESS ANALYSIS FOR ONE HALF LIVE LOAD. THE INTERCEPT BEING MEASURED UNDER THE LOADS. (IN ACTUAL PRACTICE THIS TABLE IS PLACED UPON THE STRESS SHEET ALONG WITH THE DIAGRAMS USUALLY ON THE RIGHT END.)

1 Point.	2 Arch Intercepts.	3 Trial Intercepts.	4 Polygon Lever Arms Origin.	5 Moment.	6 Triangle Intercepts.	7 [illegible] Moment.	8 Intercepts [illegible] B.
R_1							(2[illegible].64)
1	8.[illegible]	[illegible]	[illegible]	[illegible]	1[illegible]	16[illegible]	[illegible]
2	18.[illegible]0	1[illegible]	24.[illegible]	[illegible]	1[illegible]	4[illegible]	[illegible]
3	21.[illegible]	1[illegible]	[illegible]	3[illegible]	1[illegible]	61[illegible]	[illegible]
4	2[illegible].6[illegible]	1[illegible]	[illegible]	[illegible]	1[illegible]	[illegible]	2[illegible]
5	24.[illegible]	[illegible]	4[illegible]	[illegible]	1[illegible]	[illegible]	[illegible]
6	[illegible]	21.[illegible]	4[illegible]	[illegible]	14.[illegible]	64[illegible]	[illegible]
7	2[illegible].[illegible]0	2[illegible]	4[illegible]	1[illegible]6	14.1[illegible]	3[illegible]	[illegible]
8	2[illegible]	[illegible]	[illegible]	11[illegible]	1[illegible]	[illegible]	[illegible]
9	2[illegible]	[illegible]	[illegible]	1[illegible]	1[illegible]1	[illegible]	[illegible]
10	[illegible]	[illegible]	[illegible]	14[illegible]	1[illegible]	[illegible]	2[illegible]
11	[illegible]	2[illegible]	6[illegible]	1[illegible]	12.1[illegible]	7[illegible]	[illegible]
12	[illegible]	24.1[illegible]	[illegible]7.60	1[illegible]	11.[illegible]	7[illegible]	2[illegible].44
13	[illegible]	24.2[illegible]	71.[illegible]5	17[illegible]	11.1[illegible]	7[illegible]	[illegible]4
14	[illegible]0	24.2[illegible]	[illegible]	1[illegible]	1[illegible]	[illegible]	2[illegible]3
15	3[illegible].[illegible]0	24[illegible]	7[illegible].[illegible]0	1[illegible]	1[illegible]	[illegible]	[illegible]
16	[illegible]	24.1[illegible]	[illegible]	[illegible]	[illegible]	7[illegible]	[illegible]52
17	[illegible]	[illegible]	[illegible]	[illegible]	9[illegible]	7[illegible]	[illegible]
18	[illegible]	[illegible]	91.[illegible]	[illegible]	8.4[illegible]	76[illegible]	[illegible]61
19	[illegible]	[illegible]	9[illegible].1[illegible]	[illegible]	7.[illegible]	7[illegible]	[illegible]1
20	[illegible]	[illegible]	[illegible]	22[illegible]	7[illegible]	7[illegible]	[illegible]
21	[illegible]	[illegible]	1[illegible]	[illegible]	6.[illegible]	7[illegible]	2[illegible]
22	2[illegible]	21.[illegible]	1[illegible]	[illegible]	6.[illegible]	6[illegible]	2[illegible]
23	[illegible]	21.[illegible]	111.[illegible]	[illegible]	[illegible]	6[illegible]	2[illegible].49
24	24.75	20.[illegible]	11[illegible]	[illegible]	[illegible]	6[illegible]	2[illegible].48
25	23.60	19.[illegible]	11[illegible].75	[illegible]	4.[illegible]	[illegible]	[illegible]48
26	[illegible]1.80	17.7[illegible]	12[illegible]	[illegible]0	4.1[illegible]	[illegible]	2[illegible].47
27	17.[illegible]	17.[illegible]	1[illegible]	1[illegible]	[illegible]	4[illegible]	[illegible]46
28	8.50	7.[illegible]	1[illegible]7	11[illegible]	1.1[illegible]	16[illegible]	[illegible]44
R_2			1[illegible]0				([illegible]44)
Totals	7[illegible]9.3[illegible]	37[illegible]		44[illegible]3	2[illegible]7.4[illegible]	177[illegible]	57[illegible]

Pt.	9 Trial Polygon True Intercepts.	10 Arch True Intercepts.	11 Ordinates for Deflection Polygon Trial Polygon.	12 Ordinates for Deflection Polygon Arch.	13 True Polygon Intercepts.	14 True Moment Intercepts.	15 B. M. Ft.-Lbs.	16 Resultant Thrust in Lbs.
R_1	(2[illegible].64)	(2[illegible].33)			([illegible])	(+0.47)	— 7[illegible]	234[illegible]0
1	—12.33	—16.83	—2[illegible].22	—33.66	—15.41	—1.42	—21[illegible]	182[illegible]
2	— 6.52	— 6.83	—10.98	—12.66	— 6.[illegible]	[illegible]0.07	+ 9[illegible]	171[illegible]
3	— 2.86	— 3.53	— [illegible].03	— 7.06	— [illegible]	+0.04	+ [illegible]	167[illegible]
4	— 1.59	— 1.74	— 3.07	— 3.48	— 1.38	+0.24	+ 6[illegible]0	164[illegible]0
5	— 0.48	— 0.60	— 0.96	— 1.2[illegible]	0.60			16[illegible]
6	— 0.43	— 0.67	+ 0.94	+ 1.[illegible]	+ 0[illegible]	—0.12	+ 1[illegible]0	16[illegible]
7	— 1.18	— 1.67	+ 2.44	+ 3.34	+ 1.47	—0.29	+ 3[illegible]0	161[illegible]
8	— 1.94	— 2.42	+ 3.69	+ 4.84	+ 2.42	—[illegible]		16[illegible]
9	— 2.44	— 3.17	+ 4.84	+ 6.34	+ 3.[illegible]	—0.12	+ 1[illegible]	1[illegible]
10	— 2.95	— 3.67	[illegible].84	+ 7.[illegible]4	+ 3.67			1[illegible]
11	— 3.30	— 4.17	+ 6.4[illegible]	+ 8.34	+ 4.12	+0.65	+ 7[illegible]	1[illegible]
12	— 3.56	— 4.47	+ 6.99	+ 8.94	+ 4.45	+[illegible].02	+ 4[illegible]	1[illegible]
13	— 3.66	— 4.62	+ 7.24	+ 9.24	+ 4.[illegible]3	+0.[illegible]	+ 6[illegible]	1[illegible]
14	— 3.72	— 4.67	+ 7.39	+ 9.[illegible]	+ 4.65	—0.0[illegible]	+ [illegible]	1[illegible]
R_2	(20.44)	(25.33)			([illegible].11)	(—0.2[illegible])	3[illegible]	[illegible]1[illegible]
15	— 3.67	— 4.67	+221	+2[illegible]	+ 4.[illegible]	+0.0[illegible]	+ 1[illegible]	1[illegible]
16	— 3.[illegible]8	— 4.62	+ 16	+[illegible]76	+ 4.[illegible]0	+0.12	+ 1[illegible]	1[illegible]
17	— 3.4[illegible]	— 4.47	+278	+[illegible]	+ 4.[illegible]	+0.[illegible]1	+ 31[illegible]	1[illegible]
18	— 3.1[illegible]	— 4.17	+192	+[illegible]42	[illegible]	[illegible]0.18	[illegible]	1[illegible]
19	— 2.8[illegible]	— 3.67	+170	+21[illegible]	+ [illegible]			1[illegible]
20	— 2.40	— 3.17	+138	+180	+ [illegible]	[illegible]0.17	+ 24[illegible]	159[illegible]
21	— 1.7[illegible]	— 2.42	+102	+134	+ 2.1[illegible]	[illegible]	+ [illegible]	1[illegible]
22	— 1.26	— 1.67	+ [illegible]	+ 90	+ 1.[illegible]	[illegible]14	+ 1[illegible]	161[illegible]
23	— 0.51	— 0.67	+ [illegible]	+ 3[illegible]	+ 0.64	—0.0[illegible]	+ [illegible]	16[illegible]
24	[illegible]0.18	— 0.[illegible]	— [illegible]4	— [illegible]	— 0.[illegible]			16[illegible]
25	— 1.48	— 1.74	— [illegible]	— 8[illegible]	— 1.8[illegible]	—0.1[illegible]	— 1[illegible]	16[illegible]
26	— [illegible].77	— 3.[illegible]3	—123	—1[illegible]2	— [illegible]	—[illegible]4	— 6[illegible]	16[illegible]
27	— [illegible]16	— [illegible].8[illegible]	—2[illegible]4	— [illegible]	— [illegible]2	—[illegible]	— 2[illegible]	17[illegible]
28	—12.8[illegible]	—1[illegible].83	—[illegible]14	—28[illegible]	—16.11	—[illegible]2	— [illegible]	18[illegible]
Totals			—701	—[illegible]11				

	17 Normal Thrust lbs.	18 S[illegible]	19 d [illegible] Depth inches.	20 [illegible]	21 I for 1 in. width [illegible]	22 No steel Max. Comp. [illegible]	23 With steel Comp. lbs. in Concrete.	24 With steel In steel [illegible]
R	[illegible]	4[illegible]						
1	18[illegible]	[illegible]	6[illegible]	[illegible]	[illegible]	4[illegible]	[illegible]	[illegible]
2	1[illegible]	[illegible]	4[illegible]	[illegible]	[illegible]	4[illegible]	[illegible]	1[illegible]
3	16[illegible]	1[illegible]	[illegible]	[illegible]	4[illegible]	4[illegible]	[illegible]	1[illegible]
4	16[illegible]	1[illegible]	[illegible]	[illegible]	4[illegible]	[illegible]	[illegible]	1[illegible]
5	16[illegible]	1[illegible]	[illegible]	[illegible]	[illegible]	4[illegible]	[illegible]	1[illegible]
6	16[illegible]	1[illegible]	[illegible]	4[illegible]	[illegible]	4[illegible]	[illegible]	[illegible]
7	16[illegible]	1[illegible]	[illegible]	4[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
8	1[illegible]	1[illegible]	[illegible]	4[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
9	1[illegible]	1[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
10	1[illegible]	1[illegible]	[illegible]	4[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
11	1[illegible]	1[illegible]	[illegible]	4[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
12	1[illegible]	1[illegible]	[illegible]	4[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
13	1[illegible]	1[illegible]	[illegible]	4[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
14	1[illegible]	1[illegible]	[illegible]	4[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15	1[illegible]	1[illegible]	[illegible]	4[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
16	1[illegible]	1[illegible]	[illegible]	4[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
17	1[illegible]	1[illegible]	[illegible]	4[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
18	1[illegible]	1[illegible]	[illegible]	4[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
19	1[illegible]	1[illegible]	[illegible]	4[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
20	1[illegible]	1[illegible]	[illegible]	4[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
21	1[illegible]	1[illegible]	[illegible]	4[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
22	161[illegible]	1[illegible]	[illegible]	4[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
23	1[illegible]	1[illegible]	[illegible]	4[illegible]	[illegible]	[illegible]	[illegible]	1[illegible]
24	16[illegible]	1[illegible]	[illegible]	[illegible]	4[illegible]	[illegible]	[illegible]	11[illegible]
25	16[illegible]	1[illegible]	[illegible]	[illegible]	4[illegible]	[illegible]	[illegible]	1[illegible]
26	16[illegible]	1[illegible]	[illegible]	[illegible]	4[illegible]	4[illegible]	[illegible]	1[illegible]
27	171[illegible]	[illegible]	4[illegible]	[illegible]	[illegible]	4[illegible]	[illegible]	11[illegible]
28	181[illegible]	[illegible]	[illegible]	[illegible]	1[illegible]	4[illegible]	375	[illegible]600
R_2	23[illegible]	4[illegible]						

age of the value of the arc intercepts. See Fig. 10. The next is to determine the value of the horizontal thrust, H.

This can be done by either of the equations,

$$Dh = \int_{R}^{R_2} \frac{Mny}{EI} \text{ or } Dv = \int_{R_1}^{C} \frac{Mnx}{EI}$$

$\frac{n}{EI}$ is a constant and $M = Hi$. The equations can be rewritten:

$$H = \frac{Dh\,EI}{n\int_{R_1}^{R_2} iy} \text{ or } = \frac{Dv\,EI}{n\int_{R_1}^{C} ix}$$

From which:

The point A_1 being considered as an origin, the x's being measured from A_1 the y's from the springing line A_1A_2 and the intercepts or i's from K_1K_2. See Fig. 10.

Let T = range of temperature and q coefficient of expansion, and 1 = horizontal length of span. The true deflections should be found from the equation of the arch, but approximations are used. The formula $Dh = 1qt$ is used by most authors. Burr assumes DV. The method in all cases is to assume or calculate the numerical value of Dv or Dh. The products $DvEI$ or $DhEI$ can be obtained then.

A rise or fall in temperature from that temperature by which the rib was finished and closed causes it to expand or contract. The abutments being fixed, this induces a horizontal compression for expansion or a horizontal tension for contraction.

If free to cove the rib would change by the Dis. A_1, A_1^1, = Dh. See Fig. 10. The induced thrusts must be and are sufficient to cause such movement on a free rib.

For Fahrenheit degree q = .0000066

For centigrade degree q = .000012.

E of concrete = 3000000.

For a range of 80° F. and expand of 155 ft. Dh = (.0000066x155x80) = .082 ft.

$$H = \frac{.082 \times 3000000}{.148 \times 436.3} = 38000, \text{ since } \frac{I}{n} = .148$$

and $\int_{R_1}^{C} iy = 456.3$ from calculations in previous problems.

The tabulations are carried on for only ½ the arch because it is symmetrical about the center.

If erected at 60° F. and the range was 10° F. to 100° F., the stresses would be only about ½ those tabulated.

In general steel arches readily take the temperature of the air, so that the extreme fall and rise should be allowed. On the other hand concrete, stone and brick are poor conductors, and if arch is covered with earth very slight changes of temperature take place, the lower side being over water and screened from the sun.

For a rise in temperature the stresses are just the reverse of those for a corresponding fall.

Then at the various sections the angle of the tangent to the rib with the horizontal must be found and H resolved into parallel and perpendicular components. The parallel ones = the axial thrust in rib and the perpendicular = the shear. The moments are *(ia)* times 38000.

Pt.	H.	Axial Thrust.	Shear.	B. M.
1	38000	27000	27000	—400000
1	38000	33600	19000	—210000
2	38000	35000	14500	—132000
3	38000	35500	13000	— 76000
4	38000	36000	11250	— 34000
5	38000	35800	9800	— 7600
6	38000	37300	8000	+ 8000
7	38000	37400	7500	+ 8000
8	38000	37500	6600	+ 95000
9	38000	37600	5500	+118000
10	38000	37700	4400	+133000
11	38000	37800	2200	+148000
12	38000	37875	1100	+152000
13	38000	37950	100	+162000
14	38000	38000		

Railway Section

Note: This section is devoted to methods and costs of constructing railways. It will cover road-bed and track construction, contractor's plant and organization, surveying methods and permanent way structures.

Labor Cost of Track Laying on Elevated Railways in New York City, Also Some Costs of Erecting Steel.

In ENGINEERING-CONTRACTING, May 5, the cost of Brooklyn elevated railways was given in detail. The following costs relate to track-laying on elevated roads on Manhattan Island, and, although the work was done 28 years ago, the records are given by Mr. G. Thomas Hall in such detail as to be applicable today, provided proper substitutions are made for wages.

The Second Avenue line was double track, and about 7.4 miles long, of which about 2 per cent was curved.

The contractors found the following organization the most effective for track-laying:

15 carpenters.
10 skilled laborers assisting carpenters on the guard timbers.
10 men laying steel rails.
10 men clipping cross-ties.
10 men spacing, marking and edging cross-ties.
10 unskilled laborers for derrick, distributing materials, etc.
2 horses with drivers.
3 foremen.

The clippers were kept 500 ft. ahead of the spikers, and the spikers 750 ft. ahead of the carpenters on the guard timbers. Horse power was found to be cheaper than steam in hoisting track material from the street. The cross-ties were first hoisted, distributed and spaced; then marked for camber by means of T sights, adzed and clipped. Then the steel rails were in turn distributed, lined up and spiked; then the guard timbers were distributed, ends jointed, gauged and bolted down; the inside guard being put in place and finished with strap iron before the outside one was laid. A space of about 250 ft. intervened between the gangs employed on the two ranges of guard timbers. Everything working smoothly, the above force laid about 260 ft. of *double* track per 10-hour day on tangent work.

The following was the cost to the contractor of laying complete 1,000 lin. ft. of straight *single* track:

Hoisting and distributing materials	$ 40.00
Laying cross-ties	65.00
Laying steel rails	30.00
Laying guard timbers	100.00
Strap ironing guard timbers	20.00
Incidentals, loss of time, repairing tools, etc.	25.00
Superintendence	20.00
Total for 1,000 ft.	$300.00

The contract prices were 35 cts. to 43 cts. per lin. ft. of single, straight track.

Wages of common laborers were 15 cts. per hr. The above crew of 70 men and 2 horses received about $145 a day, or practically 20 cts. per hour, per man.

The amount of materials in 1,000 ft. of single track was as follows:

250 cross-ties, 6"x6"x12', 9,000 ft. B. M.
500 cross-ties, 6"x6"x8', 12,000 ft B. M.
3,000 wrought iron clips, ½"x2½"x5½".
1,500 log screws, ¾"x6".
67 steel rails (30'), 63 lbs. per yd.
67 fish plates, ¾"x2½"x20".
268 fish plate bolts, ¾"x4".
3,000 spikes.
7,000 lin. ft. guard timber, 6'x8", 28,000 ft. B. M.
1,500 guard rail bolts, ¾"x14½".
150 log screws, ¾"x12".
2,000 lin. ft. strap iron, ½"x2½".
300 strap iron bolts, ½"x6½".
300 blunt bolts for strap iron, ½"x5".
¾ bbl. Portland cement.

It will be noted that laying the cross-ties cost about $3 per 1,000 ft. B. M., and that laying the guard rail cost about $3.60 per 1,000 ft. B. M.

The cost of 30 cts. per lin. ft. of single track is equivalent to $1,584 per mile for track-laying.

To lay one "typical crossing" consisting of two cross-over tracks (one from each main track to a center track), comprising 218 lin. ft. of single track, with 5 frogs, from switches and outside guard timbers, with inside steel guard rails, cost as follows:

Hoisting, adzing and clipping cross-ties	$18.25
Laying rails, frogs and switches	40.00
Laying guard timbers	12.50
Laying steel guard rails	4.25
Total	$75.00

This is equivalent to 35 cts. per lin. ft. of the single track.

The iron superstructure of this elevated road consisted of Warren longitudinal girders, whose upper chords rest upon the top of Warren transverse girders, supported by six-segment Phoenix columns. The weights were as follows:

	Per Lin. Ft. lbs
Transverse girders	200
Longitudinal girders	130
Bracing	8
"A" calibre columns	117
"B" calibre columns	140

The columns were erected by a gang of 7 men and a team of horses, using a derrick wagon. This gang averaged 39 columns, of 20 ft. each, erected per day, or about 4½ tons.

The same gang averaged 10 columns of 50 ft. each, or 3½ tons per day.

The columns were held temporarily in place by inserting iron wedges inside the rim of the base casting.

The cost of placing a 3,200 lb. base casting, on which the column rests, was as follows:

	Per Casting.
Uncovering pier (15 cts. per hr.)	$0.35
Moving casting from sidewalk to pier (15 cts. per hr.)	0.40
Erecting derrick and setting casting (15 cts. per hr.)	0.60
Repaving, 25 sq. ft. (25 cts. per hr.)	0.50
Washing, tarring and bricking (25 cts. per hr.)	0.35
Refilling (15 cts. per hr.)	0.15.
Preparing cement mortar (20 cts. per hr.)	0.10
Foreman and night watchman	0.50
Total labor	$2.95
¼ bbl. cement at $1	0.25
¼ bbl. sand at $1.25 per cu. yd	0.05
32 brick at $10	0.32
½ cu. yd. refuse carted away	0.38
2½ cu. ft. sand for paving	0.11
Coal tar, cement work, etc	0.11
Oil for lamps, etc	0.05
Grand total	$4.21

The above is for company work. Later on contracts were let for $3.75 per 3,200 lb. base casting, and the contractor put in 15 castings a day, as compared with 10 placed by the company's forces.

The girders were erected by a traveler on the structure, with a crew of 12 men and one engineman for the 5 hp. engine, which consumed ¼ ton coal per day. This [illegible] [illegible] [illegible] [illegible] [illegible] day [illegible] [illegible].

The [illegible] [illegible] [illegible] [illegible] [illegible] lateral bracing was [illegible] [illegible] and [illegible] [illegible] [illegible] [illegible] [illegible] painted with [illegible] [illegible] [illegible] [illegible] columns were painted with a primer.

Two coats of paint were applied, the first being an iron ore paint and second being white lead. The painting cost $1.50 per [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] of which [illegible] [illegible] was for labor.

The principal coal fields of Turkey says a recent consular report, are on the southern Black Sea coast, about 1[illegible]0 miles from Constantinople and extend from Heraclea on the west, to [illegible] on the east, about [illegible] miles. Development is greatly hindered by government regulations. Permission to work is given only to Ottoman subjects, and even then the admiralty reserves the right to purchase 60 per cent of the amount mined at a price agreed upon in the mining permit. This 60 per cent of the total mined can be sold only after having been first offered to the admiralty and refused by it. The government also claims 10 per cent of the dust or fine strained through a 1-centimeter screen (.3937 inch). A mine not worked for 3 months reverts to the government. The government levies a tax of 22 cents per ton on all coal shipped. This tax can be paid in kind, and the government is accepting coal at the present time at the rate of $2.67 per ton. The duration of a permit is for no fixed period, but as long as a mine is worked. The output of the Heraclea coal fields increased from 71,000 tons in 1881 to 625,000 tons in 1907. The company has altogether about 30 miles of railway, rolling stock consisting of some 200 trucks and [illegible] locomotives with which it can handle 4,000 to 5,000 tons per day. It has a suspended cable 3 miles long between Tchatal-Aghzy and [illegible]. It has also built a port and breakwater with traveling cranes, and can load between [illegible] and [illegible] tons per day. Between 120,000 and 140,000 tons of the Black Sea coal is shipped to Constantinople, 20,000 to 25,000 tons to Roumania, a considerable quantity to the Aegean Sea, 25,000 tons to Smyrna, and about 8,000 tons to France. The company disposes of the largest part of its output to the ships which now coal at Zonguldak. The quality of the coal is said to equal Newcastle coal.

The [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] of the [illegible] [illegible] [illegible] [illegible] [illegible], or 124.42 [illegible] [illegible] [illegible] April. [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] 25.31 miles, a total of [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] the district. In the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] for the district. In the [illegible] [illegible] [illegible] trict [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] or 15.50 [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] 25.12 [illegible] [illegible] the district.

The Canadian Northern Ry. has let contracts for [illegible] 100 miles of railway in Western Canada. The contracts were awarded to the following firms: Cowan Construction Co., Winnipeg, Man.; Northern Construction Co., Winnipeg, Man.; N. Boyd, Winnipeg, Man., and Janse & McDonell, Lethbridge, Alberta.

Water-works and Sewer Section

Note: This section is devoted to methods and costs of constructing sewers and water-works. It will cover the construction work for all details of water supply and sewerage, including sewage purification and water filtration.

The Sources of and the Methods of Developing Long Island Water Supplies.*

General Geologic Conditions.—From the Connecticut shore of Long Island Sound the rock dips rapidly, approximately [illegible] ft. to the mile. Overlying the rock are beds of clay and gravel brought down by the [illegible] [illegible] [illegible] Long Island Sound at its western end [illegible] [illegible] [illegible]. The deep bays on the north shore [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]. They were probably formed by the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] into the land [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]

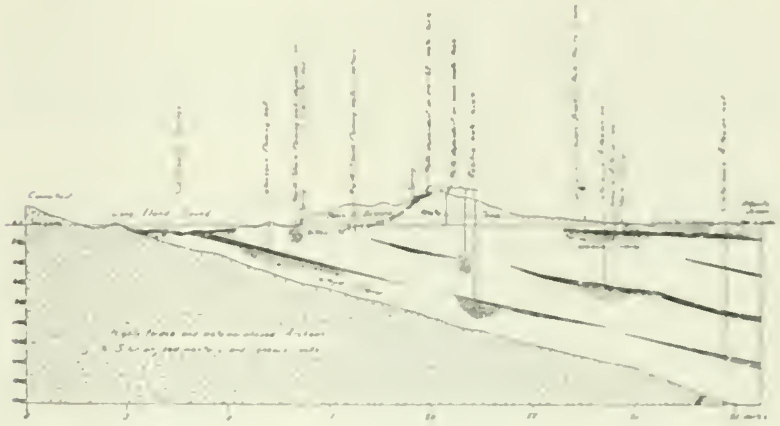


Fig. 1—Diagrammatic Cross Section of Long Island, Showing General Water Conditions and Cause of Flowing Wells.

[illegible] glaciers and on top of these lie the terminal moraines of the Wisconsin drift. (See Fig. 1.)

It has been estimated that the rate of subsidence on this part of the Atlantic border is about 2 ft. per century. In the [illegible] [illegible] of Long Island Sound are [illegible] [illegible] shoals and islands. If this district were elevated 150 ft. it would form part of the mainland, and at the above rate of subsidence it would indicate that condition as having existed approximately 7,500 years ago. At that time Long Island Sound was [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] Tertiary [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] along the present north shore. The glacier later [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] continued

tion of the [illegible] water. The [illegible] ground water table has been cut by these valleys and consequently a spring flow results [illegible] [illegible] a [illegible] [illegible] toward the Sound.

The [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] of the moraine. Under the yellow gravel is the blue clay formation [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]

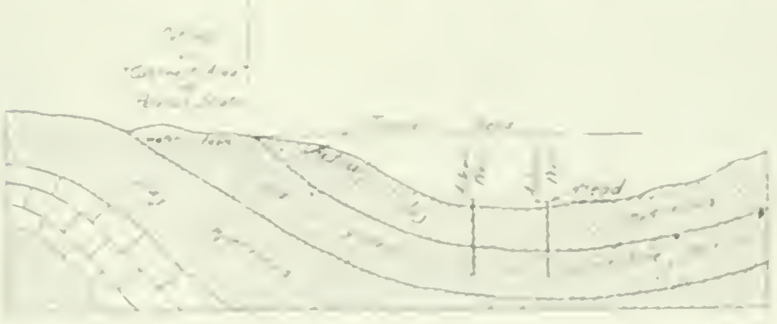


Fig. 2—Diagram Showing Common Position of Strata Producing Artesian or Flowing Wells.

the Upper Cretaceous [illegible] [illegible] [illegible] [illegible] found on top of the bed rock.

In [illegible] to underground waters the position of Long Island [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]. The only way that it can receive any of the waters [illegible] [illegible] [illegible] [illegible] through faults in the underlying rock [illegible] [illegible] [illegible] [illegible]. It is therefore [illegible] [illegible] [illegible] the rainfall for its supply. [illegible] [illegible] [illegible] of the sands and gravels prevent evaporation and hence the scarcity of surface streams on the island. These sands and gravels, however, form an immense underground reservoir, become saturated, and water escapes both along the north and south shores. There are no underground rivers on Long Island, such a condition being possible only in limestone formations.

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*Abstracted from a paper by A. S. Farmer, read before the Municipal Engineers of the City of New York.

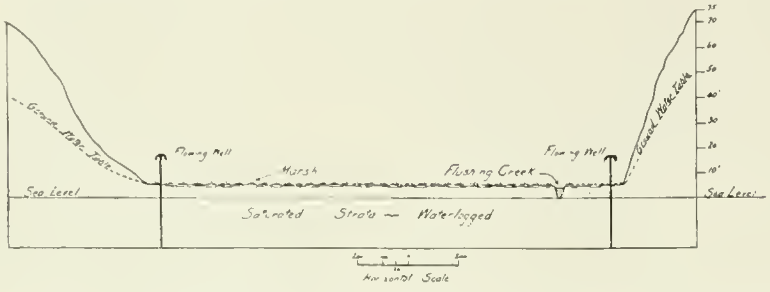

Fig. 3—Section of Flushing Creek—Station Nos. 3, 4, and 5. Citizens Water Supply C., Borough of Queens, Long Island.

Artesian Wells.—Artesian or flowing wells are common along the north shore of Long Island in the deep eroded valleys. In these re-entrant valleys the slope of the main ground water table gives a great head of water and hence the velocity of flow is considerable.

Artesian wells (see Fig. 2) are usually found where a pervious stratum lies between impervious formations; this stratum must then outcrop on the surface and pass between the impervious strata as a syncline or trough.

The common idea in regard to artesian wells is that they must be produced from a water bearing sandstone or limestone confined between impervious strata of granite. This is true enough, but on Long Island the conditions are precisely the same, only that the pervious stratum is porous sand and gravel and the impervious stratum is clay.

The artesian wells of magnitude on Long Island have their parentage in the coarse Jameco gravels which underlie the Sankaty clay and also in the Cretaceous gravels which pass under the clay sheet, but at a greater depth.

An example of an artesian well is the one at the New York State Fishery Commission, at Cold Spring, which is 6 ins. in diameter, 80 ft. deep, and is probably situated in Jameco gravel. The discharge is about 300,000 gals. per 24 hrs., with a velocity of about 2.3 ft. per second. It is located in the eroded valley of Cold Spring Harbor, just below the first pond toward the harbor.

At Oyster Bay, artesian wells have been developed extensively. This district is also in an eroded valley, and as in the former case, the main ground water table is at considerable height above the surface of the valley. The head developed by the height of the main ground water table is so considerable that flowing wells are found within a few feet of the salt water of Oyster Bay Harbor.

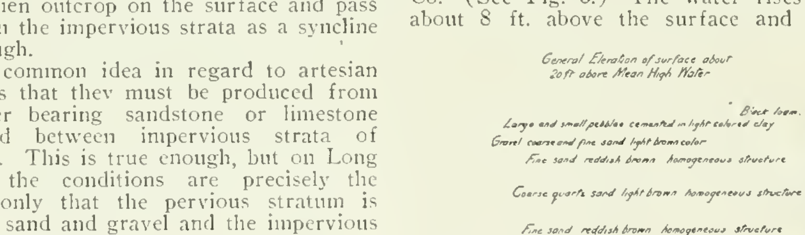
Position of main water table after ponding
Crest elevation of pond
Position of main water table before building dam
loss of head
Original elevation when flowing as a brook
Saturated Strata — Water-logged

Fig. 4—Diagram Showing That the Ponding of Any Excavated Valley Which Cuts the Main Water Table, Reduces the Spring Flow. The Discharge from the Crest Elevation of the Pond Will Be Less Than That of the Original Brook.

The phenomena of flowing wells are found in every excavated valley along the north shore. In the valley of Flushing Creek, in which the highest contour is only 75 ft., this condition is made use of for furnishing a supply of water to the pumping stations of the Citizens Water Supply Co. (See Fig. 3.) The water rises here about 8 ft. above the surface and flows into a flume to a pumping well. The ground water table generally follows the topography of the surface, and saturated or water-logged strata are found at or near the surface of the valley. The height of the water table above the foot of the cut or erosion gives a head of water on the well. In this particular case the discharge is increased by the use of compressed air, which will be explained further on.

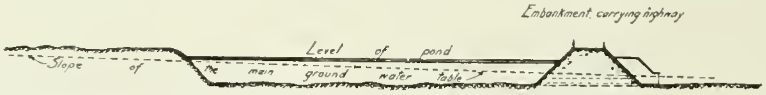
Embankment carrying highway
Level of pond
Slope of the main ground water table

Fig. 5—Diagram Showing the Method of Ponding Along the South Shore of Long Island.

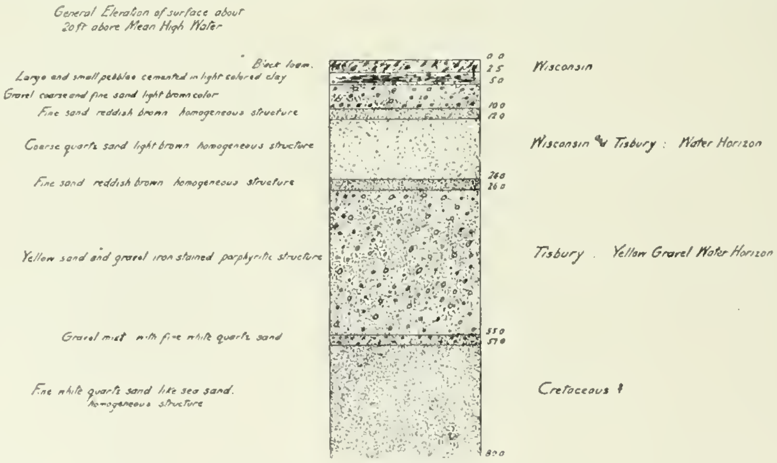
General Elevation of surface about 20 ft above Mean High Water
Black loam.
Large and small pebbles cemented in light colored clay
Gravel coarse and fine sand light brown color
Fine sand reddish brown homogeneous structure
Coarse quartz sand light brown homogeneous structure
Fine sand reddish brown homogeneous structure
Yellow sand and gravel iron stained porphyritic structure
Gravel mixt with fine white quartz sand
Fine white quartz sand like sea sand. homogeneous structure
0.0
2.5
5.0
10.0
12.0
24.0
26.0
55.0
57.0
80.0
Wisconsin
Wisconsin & Tisbury : Water Horizon
Tisbury . Yellow Gravel Water Horizon
Cretaceous ?

Fig. 6—Typical Section and Record of a Test Well at Flushing Pumping Station, Borough of Queens, L. I.

The examples of the wells shown are merely indicative of the artesian character of the sub-surface in these vicinities, and also of the immense amount of water flowing seaward and reaching its objective in the form of sub-oceanic springs.

The Ponding of the North Shore Excavated Valleys.—As stated before, the main ground water table is cut by the sides or slopes of the eroded valley. This condition results in a brook flow, running down the valley toward the Sound. It is obvious that the head of water on the brook will be considerable and the discharge a generous one. (See Fig. 4.) But in most of the cases of excavated valleys on the north shore the water is impounded by the simple expedient of building a dam across the valley, and the pond can be used either for water supply or for water power purposes.

When a dam is thrown across a valley and the water impounded in a reservoir, the position of the main ground water table promptly rises in direct relation with the level of the water in the pond. The overflow of the pond passes over a waste wier built in the dam. It is clear that the discharge over the spillway will be considerably less than the discharge from the original brook, on account of the loss of head due to the changed position of the water table.

An example of the ponding of a north shore excavated valley occurs at Cold Spring Harbor. A dam confines the waters of a chain of three ponds. The highest contour is about 200 ft. in the Tisbury formation. The pond behind this dam is about 15 ft. deep. The waste wier is 18 ft. wide and with a 2-in. head will discharge 3,600,000 gals. per 24 hrs. wasted into Cold Spring Harbor.

Ponding Along the South Shore.—The south shore of Long Island was originally a great plain of yellow sand and gravel. It was so in the Tisbury time, but the outwash from the moraine has spread some of the Wisconsin over it and also eroded and reworked the Tisbury. The surface slopes from the foot of the moraine toward

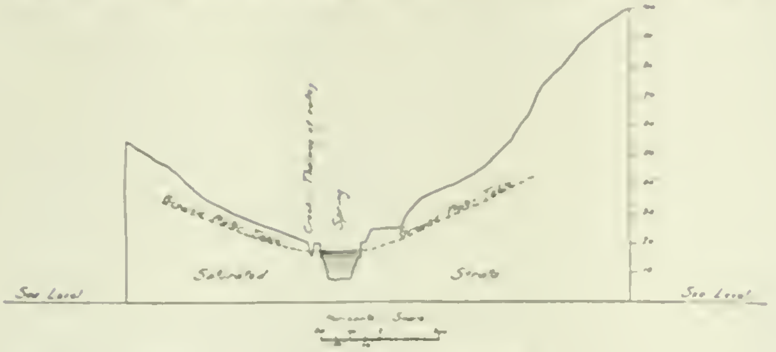

Fig. 7—Section at Flushing Pumping Station—Kassena Spring, Borough of Queens, Long Island. An Example of a Natural Spring Fed by the Ground Water Table.

the sea. The water table follows the contour of the surface and on the north shore near sea level it appears at the surface.

This condition can be taken advantage of in any depression or eroded locality near sea level. (See Fig. 5.)

From Hempstead to Eastport, a distance of 50 miles, examples of ponding can be seen. The highway along the south shore crosses these depressed areas. Wherever this occurs, the embankment carrying the highway becomes a dam which impounds the water and forms a reservoir. The position of the water table becomes changed to the level of the pond and the overflow escapes over a waste weir.

The Water Horizons on Long Island.—The strata on Long Island do not lie in conformity. Their continuity is broken in many places. (See Fig. 1.) The strata have been distorted and in many cases have disappeared entirely. The distortion of the strata was probably due to the immense height of ice on top of the land in glacial times, possibly 5,000 ft. in thickness. The pressure of the ice cap acting vertically downward on a more or less plastic foundation has squeezed out the clay. The breaks in the continuity of the strata can be accounted for by erosive action of streams and floods. In other words, the substructure of Long Island is not a homogeneous mass, and this accounts for the great difficulty in anticipating the geological section before the well boring has been made. There are three principal water horizons on Long Island, viz.: the Tisbury, the Jameco Gravel and the Lloyd Gravel.

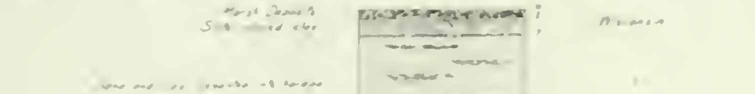

Fig. 8—Section and Record of a Test-Boring at Station No. 3, L. I. R. R. and Grove St., L. I. City, Borough of Queens

The Tisbury Water Horizon.—The Tisbury consists of the yellow sand and gravel deposits which probably extend over two-thirds of Long Island. It is the top water horizon and most of the underground water is pumped from it. It provides wells to a depth of about 40 to 60 ft., except when the overlying Wisconsin is deep. It is the home of the main ground water table. It is sometimes called the Yellow Gravel Water Horizon.

A typical section and record is shown in Fig. 6 at the Flushing Pumping Station, Borough of Queens, of the Department of Water Supply, Gas and Electricity, New York City.

The overlying Wisconsin is about 12 ft. deep, then Wisconsin and Tisbury to 20 ft., and then all Tisbury to 45 ft. below the surface. It is from the latter that the underground water is pumped. The surface indication of the water-bearing strata at this locality has been known as Kassena Spring, and is an example of a natural spring fed by the main ground water table. (See Fig. 7.) It is a natural well. At this pumping station water is pumped both from the spring and from wells. The same source of supply is tributary to both. For over 30 years this spring has fed its surface water to the pump.

The geological section was taken from a test boring made in the pond and showed two well defined water horizons separated by 2 ft. of fine sand. Underlying the lower Tisbury is a considerable depth of fine white quartz bed of impervious character, probably of Cretaceous origin.

It must, however, be borne in mind in this connection that while the surface indications may show the strata to be saturated or water logged, the yield from the wells may not be in proportion to the expected supply. The reason for such results is probably due to the fact that the strainers at the bottom of the well pipe have not been placed in coarse water bearing material of considerable depth, so that the well may have a large area to draw upon and at the same time the tendency to clog the strainer is considerably reduced.

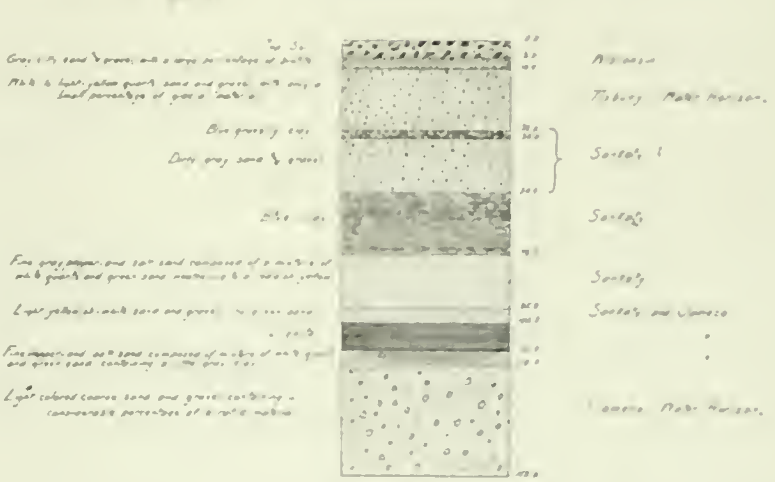

Fig. 9—Typical Section and Record of a Well at Pumping Station of the Queens County Water Co.

The quality of the Tisbury water is good, having been naturally filtered through the overlying beds of sand, except in those cases along the shore where excessive pumping lowers the level of the ground water table and salinity from the sea water creeps in.

Figure 8 shows the extreme difficulty in locating the Tisbury where it could reasonably be expected to be found. This is a section and record of a test boring at Pumping Station No. 3, Long Island City, belonging to the Department of Water Supply, Gas and Electricity, New York City.

Long Island City is at the extreme end of the Ronkonkoma Moraine, and the Wisconsin drift covers the whole of it. In its deposition it has mixed its boulder clay and sand with the Tisbury and if Tisbury occurs at all, it will occur only locally. The water bearing sand in this locality lies in the form of a syncline or trough, and has a thickness of 10 ft., about 25 to 30 ft. below the surface and yet less than 100 ft. away from the well line this water bearing sand pinched out to 1 ft. in thickness! Underneath the mixed Wisconsin and Tisbury lie the Cretaceous clays directly over bed rock, which is here located 118 ft. below the surface.

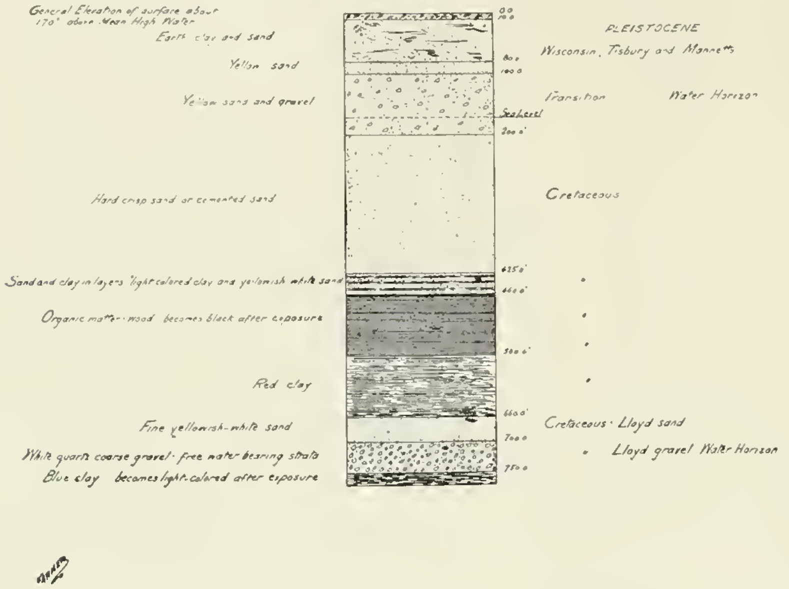
General Elevation of surface about 170' above Mean High Water
Earth clay and sand
Yellow sand
Yellow sand and gravel
Hard crisp sand or cemented sand
Sand and clay in layers light colored clay and yellowish white sand
Organic matter wood becomes black after exposure
Red clay
Fine yellowish-white sand
White quartz coarse gravel free water bearing strata
Blue clay becomes light colored after exposure
0.0
80.0
100.0
Sea Level
200.0
425.0
460.0
500.0
660.0
700.0
750.0
PLEISTOCENE
Wisconsin, Tisbury and Manhetto
Transition
Water Horizon
Cretaceous
Cretaceous · Lloyd sand
Lloyd gravel Water Horizon

Fig. 10—Section and Record of a Deep Well in the Lloyd Gravel at Lake Success, Nassau Co., L. I.

The Jameco Gravel Water Horizon.—The Jameco gravel water horizon, so called from the pumping station of the Brooklyn water works at Jameco, L. I., where the test borings were given systematic study, lies below the Tisbury. This horizon will produce artesian or flowing wells. Its coarse strata are confined by the Sankaty clay beds on top (see Fig. 1), and while these gravels have no surface outcrop they are connected with the main ground water table by the porous Tisbury strata above at places where the clay sheet has been eroded. When the clay sheet is punctured the pressure is released and an artesian flow results. The Jameco horizon is extensive over the eastern and western Long Island. It is developed principally for purposes of public water supply along the south shore of the island by the Brooklyn water works and the Queens County Water Co.

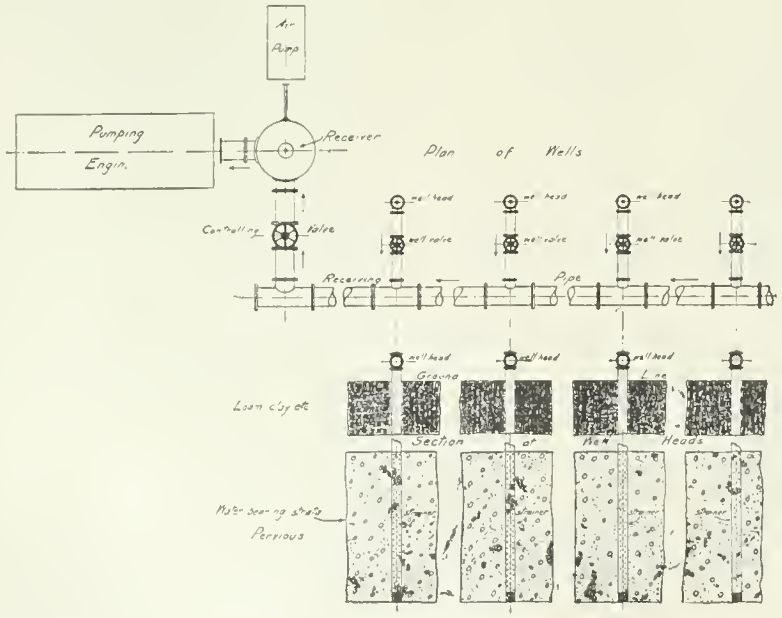

Fig. 12—Diagram Showing Typical Layout of a Well System Water-Works, Using a Vacuum for Lifting Water.

This horizon is composed of glacial gravels, the outwash of an earlier glacier than the Wisconsin. The color is generally gray and the matrix contains considerable percentages of multi-colored stones, or erratic material. The section and record at the pumping station of the Queens County Water Company, Valley Stream (see Fig. 9), is typical of the whole south shore from that point east to Babylon. These sections will show the Tisbury water horizon near the surface, the Sankaty gravels and clays below the Tisbury, and then generally a sheet of lignite above the Jameco gravels. The top of the Jameco gravels will usually be found about 100 to 110 ft. below sea level, the well strainer, of course, being entirely placed in the water-bearing material.

As explained above, the Jameco water horizon is directly connected with the main ground water table through breaks in the overlying clay sheet, and the water supply is large because of such connection, and also for the reason that the physical character of the gravels allows them to hold and retain the percolating waters. The waters from the Jameco, however, have this disadvantage, that where the water-bearing sands and gravels overlie the Sankaty blue clay and lignite beds, as they generally do, the percolating water from the upper water-bearing material causes the iron in the clay and lignite beds to leach down into the Jameco gravels and impregnate them with a strong chalybeate odor and taste. Of course, in large operations where the Jameco water is mixed with the Tisbury this condition is not very apparent, but in the case of a private water company developing water extensively from the Jameco gravel water horizon, it becomes necessary to filter out the iron.

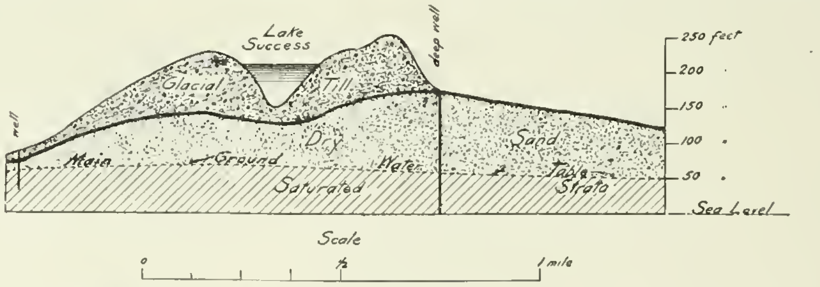

Fig. 11—Lake Success; an Example of a Kettle-Hole Lake Depending on Local Impervious Strata.

The lignite beds underneath are peat beds, and, like all peat beds, contain bog iron ore. A blue or a slate-colored clay is an evidence that iron is present in the clay, hence this water will and does carry limonite (bog iron ore), $Fe_2O_3 + 3/2\ H_2O$, in suspension.

The filter beds are gravtiy sand filters and the suspended iron forms in a crust on top. Unless this water is purified its presence forms red oxide of iron in the water pipes and becomes extremely annoying when used for domestic purposes.

Figure 9 also represents the formation of coal in the lignite or peat beds. The formation of coal and iron goes hand in hand, and we have here the coal measures and the iron mines of Long Island in their initial stage of formation.

The Lloyd Gravel Water Horizon.—This is the deepest zone of flow on Long Island. It is situated in the Upper Cretaceous sands and gravel above the bed rock (see Fig. 1), and is correlated to the Raritan formation in New Jersey. On the north shore this horizon has been developed considerably, because its depth—200 to 400 ft.—is not excessive, but on account of the dip of this stratum toward the south shore, the wells in that locality must be driven to a depth of 700 to 750 ft. to penetrate this horizon. This horizon will also produce artesian wells for the same reasons as the Jameco. On Barren Island in Jamaica Bay is an example of such a well.

Fig. 10 is a section taken at Lake Succes, which is situated about half way between Lloyd Neck and Coney Island. The top of the Lloyd sand is 600 ft below the surface and 190 ft below sea level. At Gay Head the lignite and red clay beds are 170 ft above sea level. Here in this section they show 300 and 100 ft., respectively, below sea level. This record establishes the correlation between the deep Cretaceous wells on the north shore at Lloyd Neck, Center Island, etc., and those on the south shore. This water horizon extends into New Jersey, and at Asbury Park its depth is about 1,100 ft below sea level.

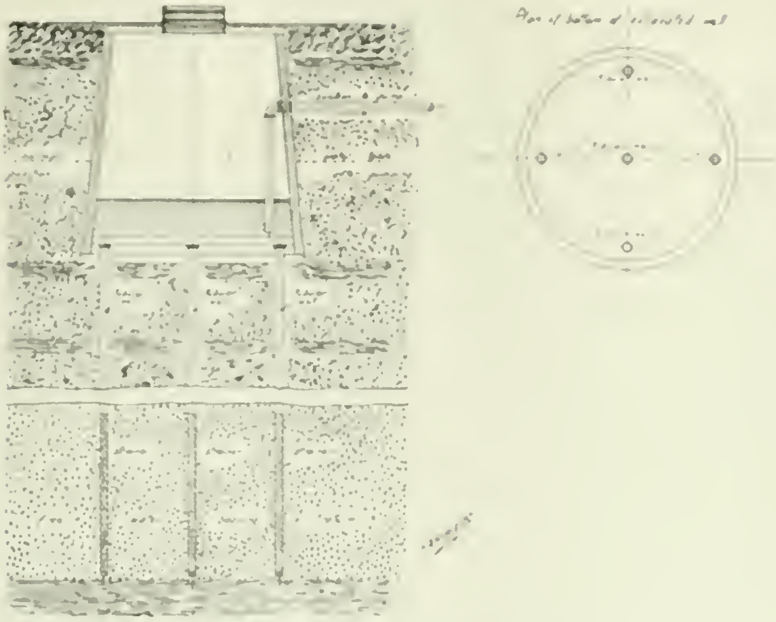

Fig. 13—Principle of the Combination Excavated and Tubular Well.

The object in drilling deep wells to the Lloyd gravel is not to get an increase in head, but to find a coarse, free, water bearing horizon.

The water of the Lloyd gravel is low in chlorine, hardness and alkalinity, and this horizon seems to be persistent and perennial. There is reason to believe that future developments in this material will produce large supplies.

The position of the section in the Lloyd gravel at Lake Success is marked in Fig. 11 as "deep well." Lake Success is a kettle-hole lake at the junction of the Harbor Hill and Ronkonkoma Moraines. It is situated high above the main ground water table and is an example of a perched water table. There are many such in the path of the moraines, but the water sheds are limited and depend on local impervious strata to preserve their water level. The economic importance of perched water tables is small on account of their limited capacity and unstable position.

Methods of Securing Underground Water Supplies on Long Island.—Aside from the sources of supply due to lakes and ponds or from reservoirs impounding flow of surface streams, from which it is no difficult problem to take supplies, there remains the vast underground water resources of Long Island.

The task of securing plentiful and generous supplies from the underground water horizons is not an easy one. If the water horizons were laid down stratigraphically, each in a horizontal plane, so that sections taken vertically anywhere would show the same formation, then the problem of underground water supply could be readily solved. But this condition is not found on Long Island. The water horizons have been generally distorted from their once horizontal position, and it becomes necessary from the data of well-boring samples to plot the contours of the different water bearing strata in order to get an idea of the limits of any particular water-bearing area. The difficulty of locating the free water bearing material for purposes of public supply is harder to overcome on the north shore of Long Island than on the south shore, for on the north shore the Wisconsin drift is of considerable depth and has mixed its rubbish of boulders and clay with the Tisbury; but on the south shore the Tisbury water bearing sands and gravels lie at or near the surface and can be more easily developed for water supply purposes. Most of the Tisbury water is pumped by using a vacuum for lifting the water. The ground water table being near the surface, the value of this method is at once apparent. Figure 12 shows a typical layout of a well system waterworks pumping from the Tisbury. The well strainers, preferably of brass, this being non-corrosive, are placed in the water-bearing strata and on the surface the well discharges through a short pipe into the main receiving pipe. Each well is independent in the system, being controlled by its own well valve. Any well or group of wells can be shut off without interfering with the operation of the remainder. The discharge of the main receiving pipe is governed by a controlling valve and the water passes into the receiver. Attached to the receiver is the air pump and the pumping engine. The function of the air pump is to create a vacuum on the entire well system. This reduces the atmospheric pressure on the water in the wells and fills the receiver. The pumping engine itself is an efficient agent of the air pump in bringing the water from below the surface. The water passes through the pump and is discharged into the force main at the required pressure.

Another type of well is the combination excavated and tubular well shown in Fig. 13. A circular excavation is made below the ground water table and a masonry shell or casing is sunk or built to some depth below it. In the bottom of the excavated well tubular wells are driven and the strainers placed in a free water bearing stratum. The level of the water in the excavated well will rise to the level of the ground water table. A suction pipe from the pump is introduced. The reservoir part of the well serves for storage and for a water seal to the suction pipe. The influence of the pump is felt in all the tubular wells and draws the water upward from its underground position into the reservoir above and thence into the pump. This type of well will deliver large quantities of water. An example of such a well may be seen at Pumping Station No. 1, Long Island City. While the influence of the pumping engine and the air pump produces satisfactory results in drawing water from the underground supply, there is a more powerful agent than steam, viz. the air compressor. The duty of the air compressor is to furnish air under heavy pressure in the well pipe. The general method of using compressed air in lifting water is shown in Fig. 14.

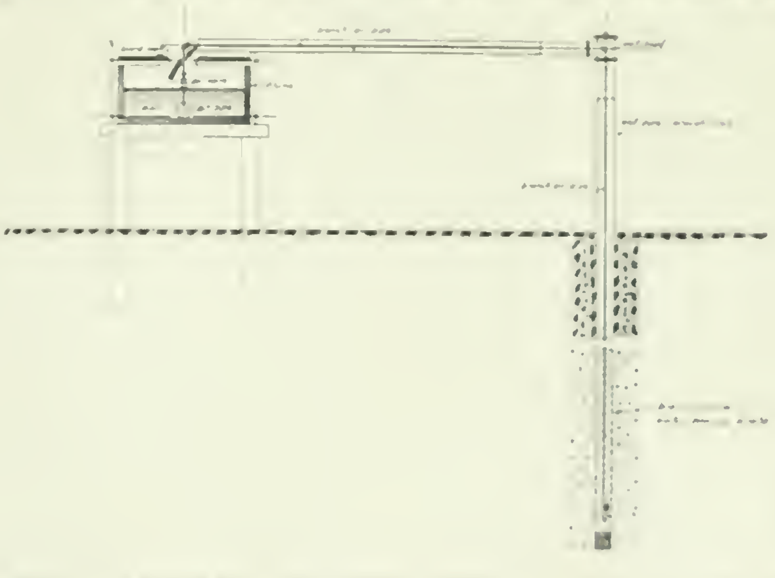

Fig. 14—Section of Flume and Well, Showing Method of Using Compressed Air in Lifting Water

The main air pipe runs from the receiver of the air compressor either on top of the flume or on the floor, and at each well it is tapped by a branch air pipe. This branch air pipe extends down into the well and is turned upward at the bottom. At each pulsation of the compressor a corresponding pulsation is made in the well pipe and the water is forced upward and discharges into the flume. It is evident that compressed air under heavy pressure is powerful and far reaching in its action in the water-bearing strata. It draws the water from remote places and compels its presence in the well pipe. The use of compressed air in lifting water adds greatly to the supply. An excessive pressure may cause fine sand to be drawn through the strainer and forced upward in suspension, producing subsequent damage to the pump valves. Under the influence of compressed air the water flows into the flume and thence into a receiving well, from which it passes through the pumps and into the water-mains.

This elementary method has been modified and improved for pumping from deep wells. (See Fig. 15.) The essential and governing principle in this type of air lift is that the air supply can be controlled in the well pipe itself. This is accomplished by means of a valve in the air pipe in the well, these valves being regulated by a wheel at the top of the well head. The air can be admitted at variable water levels, a valuable consideration, where several water horizons are penetrated. Especially valuable in the operation of deep wells in excellent water-bearing strata is the fact that the heavy head of water in the pipe, due to the presence of the ground water table, can be thrown off and the well compelled to draw for its supply from the lower and greater water horizon.

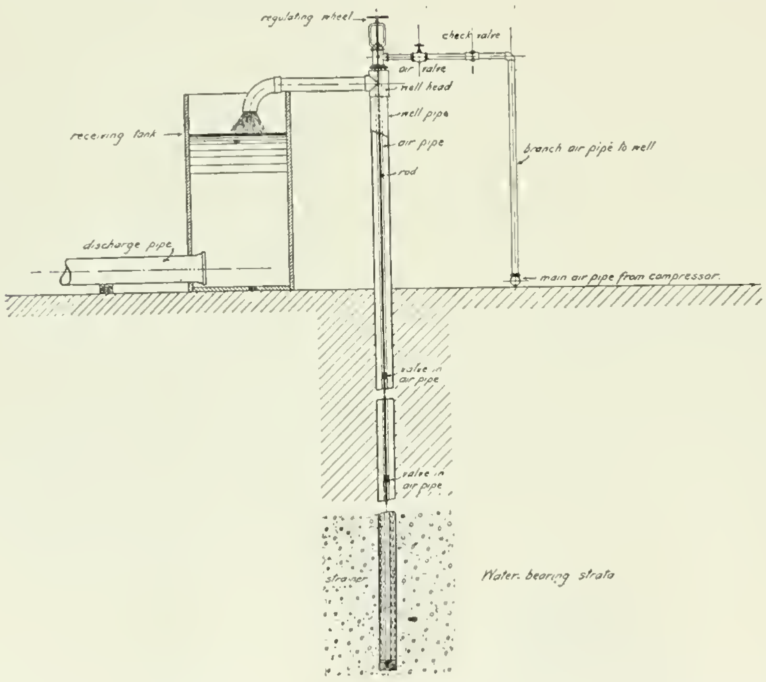

Fig. 15—Principle of the Air Lift for Use in Deep Wells of Variable Water Levels. The Air Can Be Admitted at Different Points in the Well Pipe.

This principle is made use of in the operation of the Jameco Pumping Station at Jameco, Long Island. The water is there being lifted from the deep wells in the Jameco gravel water horizon.

Another method of obtaining underground water on Long Island is by means of infiltration galleries. The essential principle involved in this method consists in excavating a trench or tunnel below the level of the ground water table. By extending the gallery or ditch to a very considerable length, with a slope less than that of the surface of the ground, the underground water can be brought to the surface by gravity alone. This method can be applied generally only along the south shore of the island, where the ground water table is near the surface and where its slope is appreciable. The ditch or collecting gallery is constructed across the path of the underflow, and the water drawn therein flows by gravity to a receiving well, from which it can be pumped or the water may be piped to a reservoir on the surface.

Conclusions.—A summary of the foregoing establishes the following facts: Long Island and the islands in the Sound or off the southern coast of New England have a common origin. The basal clays on top of the bed rock, created by erosion or corrosion from the rocks on the mainland, are covered by the sands, gravels and boulder clays, later brought down by glaciers or from outwash from the terminal moraines of the glaciers.

The strata do not lie in conformity, and the clay sheet confining the lower water horizons has been broken or eroded away, producing the phenomena of flowing wells. The supply of water is dependent on the rainfall and gives rise to the presence of the ground water table which fluctuates vertically in proportion to said precipitation. The ground water table follows the topography of the surface and its divide between the underflow toward the north and the south shore will generally be at about the same geographical position as the divide of the surface waters. The soil being porous, there is little evaporation, and for the same reason a scarcity of surface streams, which not only carry the run-off, but at the same time carry away some of the water on the ground water table where the valleys or depressions cut it and cause its waters to flow into the stream. The importance of the natural wells or kettle holes in the Tisbury formation and also the excavated wells in the same formation, to which latter class the infiltration gallery belongs, is significant. The large area of the upper water horizon, and its nearness to the ground surface, makes possible a large supply of water by pumping from shallow wells. The waters of the Jameco gravel horizon, while of generous proportions, generally carry iron in suspension and should be filtered when necessary. The future development of the Lloyd gravel horizon should give large supplies.

The supply from the perched water tables is insignificant and only of local importance.

Attention is called to the ponding along both the north and the south shores and to the water wasting over the spillways of the dams; also to the decided artesian character of the waters along the north shore. Exploitation of this field should produce an abundant yield. The value of compressed air as an agent in expelling the underground waters is apparent.

The development of the infiltration gallery should become an important factor in enlarging the public water supply.

The Cost of Five Slow Sand Filter Plants—Four Small and One Large.

While there is more or less scattered information relative to the first cost of filter plants, an engineer can usually find little to guide him in making preliminary or rough estimates of cost. The following data should, therefore, prove of value to waterworks engineers:

Mr. William Wheeler gives the following relative to a slow sand fillter built in 1895 at Ashland, Wis. This is the first sand filter plant in America to be covered with masonry. The 3 filter beds have an area of ½ acre. They are so located on the lake shore that it was necessary to build a pile bulkhead around three sides of the filter beds. The walls are of concrete and brick, 3 ft. thick at the bottom and 2 ft. at the top. The beds are roofed with groined elliptical brick arches (15¾ ft. span), resting on brick pillars, and backed with concrete. Two courses of brick laid flat form the arch rings (5 ins. thick). The floor is of concrete only 3 ins. thick. It is below the lake level, which necessitated building a cofferdam during construction. The sand beds are 4 ft. thick resting on 9 ins. of gravel. The work of construction was entirely by day labor. The cost was as follows:

470 lin. ft. cofferdam (not with earth filling)	$ 1,720
Handling water	493
6,943 cu. yds. earth excavation	3,233
340,400 bricks, laid in walls	6,237
45,000 bricks, laid in piers	827
349,550 bricks, laid in roof arches	6,755
Centers for roof arches (labor and materials)	1,157
37 manholes	724
House over effluent chamber and sump well	627
1,000 cu. yds. concrete	5,977
Vitrified collecting pipes, laid	116
Cast iron collecting pipes, laid	639
Cast iron supplying pipes, laid	725
Pipe, pipe connections, pump, etc.	729
880 cu. yds. gravel in filter beds	1,949
3,335 cu. yds. sand in filter beds	4,201
Sundries	2,268
Engineering and superintendence	1,800
Total	$40,178

This is equivalent to about $80,000 per acre, but, had it not been for the difficult conditions and winter work, the cost would have been $5,000 less, or $70,000 per acre, including pump well, sump well, effluent chamber, piping and housing. A further reduction of 10 to 15 per cent in cost could be effected where building stone and suitable sand and gravel were near at hand.

This plant filtered 1,100,000 gals. per day, or at the rate of 2,200,000 gals. per acre per day. It required 10 scrapings of sand per year, removing 610 cu. yds. of sand, which was equivalent to 1.52 cu. yds. of sand scraped per million gallons. The cost of this scraping was 62 cts. per million gallons, or 40 cts per cu yd of sand, the cost of scraping a bed of one-sixth acre being as follows:

3 men scraping ½ day at $1.50	$2.25
2 men wheeling in filter ½ day at $1.50	1.50
1 man tending basket at bottom ½ day at $1.50	0.75
2 men [illegible] and dump at bottom ½ day at $1.50	1.50
1 man wheeling away at top	[illegible]
1 single team to haul [illegible]	[illegible]
Tools and sundries	[illegible]
Total for 1-6 acre	[illegible]

There were 21 cu yds of sand (plus the mud) removed at each cleaning of a bed, making the cost 40 cts per cu yd. The dirty sand was not washed, but new clean sand was delivered by contract and placed for $1 per cu yd. Hence the cost of scraping sand and of replacing with new sand cost $1.40 per cu yd of sand scraped, or $2.13 per million gallons. Adding 13 cts to this for superintendence, etc., the total cost of filtering was $2.26 per million gals. At 5 per cent interest on the first cost of the plant, the capital charges are $5.05 per million gallons, making a total of $7.31 per million gals.

Mr J W Ledoux gives the following data relative to a small (½ acre) sand filter plant built in 1898 at Berwick, Pa. It has a nominal filtering capacity of 1,500,000 gals per day. The filters are built in 3 compartments (not roofed), each having 7,500 sq ft effective filtering area, or about 85 ft square. A vertical section through the filter beds shows 30 ins of sand, 6 ins of gravel, 3 ins of concrete floor and 8 ins of puddle. The main drains are 12 in vit. sewer pipe; the laterals are 4 in tile, spaced 6 ft apart, set in depressions in the concrete. The side walls are of rubble, outside of which is the embankment. The cost, including a $2,000 gate house and accessories, was as follows:

6,772 cu yds excavation at $0.241	$1,[illegible]
528.3 cu yds stone masonry filter basin, at $5.541	2,927.31
24 cu yds brick masonry filter basin at $9.16	[illegible]
304.7 cu yds concrete filter basin, at $6.152	1,872.43
[illegible] sq yds plastering and forming gutters at $0.243	[illegible]91.60
3,2[illegible] lin ft 4-in tile drain in place at $0.065	[illegible]7.20
246 lin ft 12-in collecting drain at $0.654	160.88
286 lin ft 12-in clean-out drain at $1.198	342.61
281 lin ft 12-in cast iron inlet and outlet pipes at $1.571	441.[illegible]
200 lin ft 14-in cast iron filter discharge at $2.392	478.36
517 cu yds puddle at $0.739	[illegible]
65[illegible] tons gravel in filter bottom at $2.115	1,386.62
2,6[illegible].83 tons sand in filter bottom at $1.679	4,42[illegible].10
97.2 cu yds stone masonry gate house at $7.2[illegible]	[illegible]
10.75 cu yds brick masonry gate house at $7.38	79.33
12[illegible].3 cu yds excavation and back fill gate house at $[illegible]	12[illegible].43
Roofing (slate), woodwork and painting gate house	[illegible].81
[illegible] lbs flange pipe (16 in.) gaskets, etc., at $[illegible]	[illegible].26
Registering and weir apparatus	[illegible]
Valves (6 to 12-in.) with boxes and hand wheels	[illegible].59
Superintendence and engineering	[illegible]
Incidentals	1,[illegible]
Total	$18,[illegible]

Since the filter bed has a total area of 22,500 sq ft, the cost was about $0.80 per sq ft (including cost of the gate house), or $35,700 per acre. This cost is equivalent to $12,000 per million gals of daily capacity. The "superintendence and engineering" was 4 per cent of the total cost.

Mr G N Houston gives the following relative to a slow sand filter plant built in 1899 at Nyack, N Y. The filter beds are not roofed. There are two beds 74x116 ft each, having a combined filtering area of 0.38 acre. The maximum consumption of water at Nyack was 750,000 gals per day, which would require a filtering capacity of 1,900,000 gals per acre per day, if only one bed were used. But, as a matter [illegible], both beds are used except when one is being cleaned. The raw water is drawn by gravity from a nearby creek. The filter is located in a swamp, adjacent to the creek, which made its construction expensive. In order to deliver the creek water by gravity to the filter, it was necessary to excavate for the filter beds to a depth of 10 ft. The material was a wet treacherous clay whose banks would crack and slip so that it was necessary to support the side walls on piles. The clay was spaded out in chunks that were lifted by hand into wagons. Temporary plank roads had to be laid. Sheet piles were driven all around the filter beds and left in place. Bents of bearing piles were driven underneath the retaining walls, capped and floored with plank. On this pile foundation, which cost $3 per lin ft of wall, was built a small concrete retaining wall for a height of 3 ft 8 ins, the top of this wall being about the same elevation as the top of the sand in the filter bed. The earth slope above the retaining wall was paved with 8 ins of concrete and vitrified brick for a length of about 6 ft measured up the 1½ to 1 slope. The division wall was also supported on a pile foundation, and was of concrete up to the level of the surface of the filter sand, and above that it was of vitrified brick 2 ft thick. The work was done by contract at the following cost to the village:

Excavation (10½ ft deep and about 7,000 cu yds.)	$5,[illegible]
Grading and soiling	1,[illegible]
Sheet piles 66,000 ft B M at $[illegible]	[illegible]
Bearing piles 372 at $4.12	1,5[illegible]
Hemlock caps and floor	538
Yellow pine caps and floor	[illegible]
Concrete floor 10½ in thick ($1.[illegible] per sq yd)	2,[illegible]
Concrete walls 430 cu yds at $4.40	1,892
Concrete slope paving	484
Brick slope paving 13.45 cu yds at $8.40	113
Bluestone curb	250
Vitrified pipe drains (about 1,400 lin ft of 6-in and 230 ft of 12-in.)	347
Gravel (12 ins.) and sand (36 ins.) [illegible] cu yds at $2.1[illegible]	[illegible]
House over regulating chamber	[illegible]
Pipe laying	[illegible]
Miscellaneous	250
Total	$24,737
Engineering ($3,644) and inspection ($713)	4,357
Total, 0.38 acres at $76,[illegible]	$29,094

This is an unusually high cost, due to the conditions above given, and to the fact that the work was dragged along, which made the expense of engineering and inspection high. The price of filter gravel and sand was high as it was brought by scow from Long Island.

The above costs include a clear water well 25 ft in diameter, with side walls 12 ft high, and a dome shaped roof of concrete.

The plank "floor" includes not only the floor laid on the bearing piles but a 1 in hemlock floor laid over the entire bottom of the filter bed on which the concrete was placed.

Mr R D Chase gives the following data relative to a sand filter and aeration plant built in 1899 for Superior, Wis., to remove the iron from water from driven wells. There are 3 filter beds, each 67x116 ft, and with these in operation there is [illegible] acre filtering area and a capacity of [illegible] gals daily, or [illegible] gals per acre per day. This rapid rate of filtration is permitted because there is no removal of bacteria.

The pure water reservoir is [illegible]x116 ft. The floor, walls and roof are of concrete, the piers supporting the roof being of brick 20 ins square and 12 ft high. The floor is of inverted groined arches and the roof is of groined arches, 12 ft span and 2½ ft rise, 8 ins thick at the crown. The roof is covered with 2 ft of earth.

The excavation was very wet, expensive to handle, the actual cost being [illegible] cts per cu yd.

Each filter bed has 20 manholes, 3 ft diam., 4 ft high of concrete 8 ins thick, with double covers of steel plates.

The outside walls of the filter beds are 2½ ft thick at the top and 3½ ft thick at the base.

The construction of the pure water reservoir is similar to that of the filters and the reservoir has a capacity of [illegible] gals.

The main underdrains are 20 in tile laid in concrete beneath the floor. The lateral drains are of 6 in tile 12 ft apart. The gravel bed is 1 ft thick and the sand bed is 3 ft thick. The sand was dredged from the lake. Under normal conditions 4 ft of water is kept on top of the sand.

The outside dimensions of the 3 filter beds and the pure water reservoir, all under one roof, are 116 ft x 275 ft.

The construction was done by day labor, working under a contractor who was paid a percentage for supervision. Laborers were inefficient, yet received $2 a day. The actual cost was as follows:

Filters and pure water reservoirs—	
14,000 cu yds excavation at $[illegible]	$7,[illegible]
2,000 cu yds backfill (roof, etc.) at $0.29	[illegible]
[illegible] cu yds concrete at $7.85	[illegible]
Arch centering	1,[illegible]10
[illegible] cu yds brickwork at $[illegible]	1,[illegible]
Tile pipe	860
[illegible] cu yds filter gravel in place at $1.97	2,[illegible]70
1,600 cu yds filter gravel in place at $3.04	4,864
800 cu yds filter gravel in place at $0.97	776
Aerator	470
Miscellaneous charges	2,[illegible]
Engineering and percentage to contractor	9,204
Total	$46,[illegible]
Land	6,260
Iron pipe, pump, pump house, etc.	[illegible]70
Grand total	$8[illegible],434

Since the total area was 116 × (275 − 20) = 29,580 sq ft (0.68 acre), the excavation must have averaged about 13 ft deep.

It will be noted that the filter gravel was exceedingly expensive, as was most of the filter sand. The sand for one bed, however, was obtained without dredging and at a cost of only 97 cts per cu yd.

The cost of cleaning a filter bed is as follows:

[illegible] men scraping 3 hrs at [illegible] cts	$[illegible]
1 team hoisting 2 hrs at [illegible] cts	[illegible]
[illegible] men loading 2 hrs at [illegible] cts	[illegible]
[illegible] men smoothing 2 hrs at [illegible] cts	[illegible]
Total, scraping [illegible] cu yds at $[illegible]	$[illegible]
[illegible] cu yds new sand to be replaced, at $1	[illegible]
Grand total, [illegible] cu yds at $[illegible]	$[illegible]

About 12,000,000 gals are filtered through each bed (0.25 acre) between scrapings, so that 0.[illegible] cu yd of sand is scraped per million gals, and the cost per million gals is:

Labor scraping and removing sand	$[illegible]
Clean sand replaced	[illegible]
Total	$[illegible]

The dirty sand is removed in [illegible] by a frame, a tripod with a block and tackle being placed temporarily over each manhole during hoisting.

The following data are abstracted from

a paper by Allen Hazen and E. D. Hardy, Trans. Am. Soc. C. E., 1906, Vol. 57:

This is a slow sand filtration plant treating 70,000,000 gals. daily, and its cost was $3,356,300 (including $619,900 for land), or $47,950 per million gals. daily capacity. Assuming interest and depreciation at 5 per cent per annum, the capital charge is $7 per million gals. for an average of 67,000,000 gals. per day, and the operating expense is about $2 per million gals., making a total of $9 per million gals. filtered.

The summarized cost of the plant is as follows:

Pumping station, etc.	$ 183,600
29 filters, 29 acres, at $75,758	2,197,000
Filtered water reservoir	150,000
Lower gate house and pipe line	24,300
Land	619,900
Engineering and clerical	181,500
Total, 29 acres, at $115,735	$3,356,300
Total, exclusive of land	2,736,400

The detailed cost was as follows:

Pumping Station—

Intake, with gates and building	$ 11,500
Venturi meters, 72-in. and 54-in.	5,000
Electric lighting, engines, etc.	7,000
Four 200-hp. boilers, in place	14,800
Four Roney stakers	4,100
Two Green fuel economizers, in place	5,100
Three 36-in. centrifugal pumps and engines	42,000
Two sand-washer pumps	8,100
Piping, valves, etc.	13,100
Coal, oil and running tests	3,500
Traveling crane	1,600
Chimney (with foundation)	5,800
Building (with foundation and well)	51,000
Total, pumping station	$183,600

Twenty-nine Filters—

862,700 cu. yds. excavation, at 30 cts.	$ 258,800
299,500 cu. yds. filling at 30 cts.	89,900
Sodding and seeding slopes	7,300
Roads and drains outside of filters	16,200
Concrete tunnel under First St.	3,100
Concrete (including cement):	
36,563 cu. yds., floors, at $6.75	246,800
19,038 cu. yds., walls, at $7.35	139,900
6,964 cu. yds., piers, at $8.25	57,500
34,920 cu. yds., roof (vaulted), at $8.75	305,500
Ramps leading to tops of filters	6,800
Court paving	43,000
7,900 ft. Central underdrains, at $1.65	13,000
Interior drainage system, 29 filters, at $500	14,500
Drainage of roofs, 29 filters, at $266.	7,700
Materials placed in concrete, 29 filters, at $200	5,800
157,725 cu. yds. filter sand, at $2.65	418,000
36,500 cu. yds. filter gravel, at $2.75	100,400
Cast iron pipe and specials	117,000
Steel rising main and concrete backing	76,800
Pressure pipe system	2,600
Sand-washer pipe system	24,000
Sand washers, 19 washers and 8 ejectors	4,800
Elevated sand bins, 29, capacity 250 cu. yds. each	60,800
Exterior drainage system	25,300
Venturi meters and indicating apparatus	11,400
Sluice gates and gate valves	19,900
Regulator houses	27,300
Office and laboratory	19,700
Shelter house for workmen	4,800
Water and gas lines to buildings	11,200
Electric lighting for courts and filters	41,900
Cleaning up and miscellaneous	11,600
Total, filters, 29 acres, at $75,758	$2,197,000

Filtered Water Reservoir:

83,500 cu. yds. excavation, at 30 cts.	$ 25,100
18,000 cu. yds. filling, at 30 cts.	5,400
15,290 cu. yds. concrete, at $7.60	116,000
Gate house superstructure	3,500
Total, reservoir	$150,000

Lower Gate House:

Pipe lines	$ 6,000
Gate house	18,300
Total, gate house	$24,300

Engineering and Clerical:

General plans	$ 36,000
Surveying	32,000
Field office force	21,000
Main office force	67,000
Watchmen	4,500
Temporary office	1,000
Total, engineering	$181,500

The engineering was 6.65 per cent of the total cost of construction, which is a high percentage on so large a contract.

This Washington filter plant is similar to the Albany plant, but it cost 65 per cent more per acre, due principally to the higher contract prices, especially the price for filter sand which cost $2.65 per cu. yd. at Washington as compared with $1 per cu. yd. at Albany. It was anticipated by the Washington contractors that the cost of producing filter sand of specified cleanliness would be far greater than it really was.

In discussing the paper, Mr. J. A. Vogleson gave the following table of cost of cleaning filter sand per cubic yard:

	Washington (1906).	Albany (1899-1901).	——Philadelphia—— Belmont (1905).	Upper Roxboro' (1905).
Scraping	$0.05	$0.13	$0.21	$0.18
Removing	0.16	0.25	0.23	0.22
Washing	0.05	0.30	0.30	0.09
Replacing	0.13	0.25	0.25	0.30
Total, per cu. yd.	$0.39	$0.93	$0.80	$0.79
Rate of wages, per 8 hrs.	$1.50	$1.50	$1.75	$1.75
Cost, per million gals.	$0.60	$1.66	$1.25	$0.63

The low cost of cleaning Washington filters is due to the method used. After scraping the sand into piles, it is shoveled into an ejector and carried through a hose to a 4 in. pipe, and thence to the sand washers, and thence through pipes to the sand bins, from which it is drawn off into carts and dumped through the roof of the filter into a rotatable chute which discharges it where desired.

The cost of 30 cts. per cu. yd. for "replacing" the sand at Upper Roxboro, Phila., is the contract price, the work being done with wheelbarrows. Before the replacing was done by contract, it cost the city 52 cts. per cu. yd. by day labor, thus furnishing another one of the numberless examples of the greater efficiency of contract labor.

Traverse Work in Connection With the Triangulation of the Borough of the Bronx, With Special Reference to Accurate Measurement With Tapes.*

BY MR. EDWARD H. HOLDEN.†

The essentials of a topographical bureau are as follows:

(1). A topographical map on a scale embracing the entire district, showing contours, rivers, roads, etc.

(2). Section sheets of the same on larger scale showing more detail.

(3). Traverse sheets with range lines showing the traverse lines and stations with full dimensions.

(4). General map of the entire section showing plan of streets.

(5). Sectional maps of the same on a larger scale, showing contours, street lines, monumented lines, with dimensions and grade elevations.

(6). Accurate and complete record.

I shall this evening speak of the traverse work. All physical features of the earth's surface together with the improvements man has made, are located or defined in space by their three dimensions. Two dimensions are generally given by latitude and longitude, or by rectangular co-ordinates; the third dimension by its elevation above some datum plane, generally sea level.

The co-ordinates of a point are obtained indirectly by means of traversing. A traverse is a series of lines whose lengths and directions in relation to one another are known. By referring all traverse lines to a single direction through an initial point, called the origin, we have the regular system of rectangular co-ordinates. Some means of control over the traverse work must exist if the work is to be the basis for monumenting a street layout.

Today a system of triangulation is generally adopted as that control. Formerly, where no such control was maintained, the procedure was thus: a first traverse was run and balanced in the usual way, on itself; a second traverse was run and balanced on part of the first; a third on the second, and so on, each succeeding traverse being built upon the preceding ones.

Whether you embrace the whole territory by a large traverse and cut it up in smaller areas, or build up the whole by the smaller ones, the fact remains, that if you take a point at an appreciable distance from the origin, the necessary balancing makes one doubtful of the accuracy of its coordinated position. One of the greatest sources of error in balancing is that the principle of it assumes that the error is uniform, whereas, in practice, local errors frequently occur, and, unless they are large, there is no way of detecting and locating them. Consequently your good work is vitiated by some local error, as, for example, a miscall in the tenths of a foot, or the chainman, in reading the tape upside down, counts his hundredths from the wrong tenth.

An error of this kind cannot be balanced or distributed over the entire work, but remains a local error, and at each traverse station either way this is felt, becoming proportionately as the length of the traverse increases.

The result is that when you have your district traversed and the positions coordinated, these co-ordinates are misleading and do not give the true relation between the positions, and when you project a straight line through two, three or more of your adjoining traverses, you find in the field that your intended straight line has as many bends as the number of traverses it involves.

The same thing is true for the angles of intended streets and avenues, and your instructions for laying them out will not develop the map or required angles.

It is to this end that the principle of control is brought to our aid, and by it we have our traverse runs under control to the extent of the precision of the triangulation.

In order to keep up the standard of precision in the field work one must keep an everlasting vigil on the work itself. Whenever a monument or point is used as a basis of new work it is most important to verify the correctness of its position. This may seem self-evident, but I can assure you that the neglect of this matter has resulted in [illegible] reputation for good work, more perplexity and greater worry than all the other combined causes. Where the work is new all may go well, but when you deal with monuments set years ago when instruments and methods were not up to the present standard of precision you will find inconsistencies which, if not eliminated, will certainly cause serious trouble. You will be compelled to deal with property maps, made by surveyors, which show street lines and block dimensions differing materially from the same quantities when measured on the ground. For example, suppose that in making the map of your street system it is desirable to keep the lines of a street shown on a certain field map, and suppose that the monuments as shown on the map when tested by traverse fail to give the required angles and distances, the problem for you is which shall be held? The street on the ground or that on the map? If you attempt to keep both your mistake will prove fatal. In such cases insist on a change in the map to agree with the monuments in the ground or vice versa.

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The charter of Greater New York calls for a triangulation in conformity with the methods of the United States Coast and Geodetic Survey, on which all maps are to be based.

This triangulation was begun in May, 1903, under the direction of Mr. A. T. Mosman of the United States Coast and Geodetic Survey.

In July, 1904, the President of the Borough of The Bronx began the erection of signal stations in his borough and it was my privilege to be assigned to the work. A reconnaisance survey was made showing the inter-visibility of the proposed stations. A plan of the same was submitted to Mr. Mosman from which he laid out the base net and general triangulation scheme. The base line selected was situated at Unionport and so named, its length being approximately 12,000 ft.

Sixteen triangulation towers ranging from 30 to 84 ft. in height were built, which, together with eleven buildings and two poles, constituted the 29 stations of the Borough of the Bronx.

In the construction of these stations high poles were used which materially expedited the work. These were set vertically at the proposed station and by climbing the pole until you can see all the surrounding stations, you get, in one operation, the required height of the tower.

Without its use, one must occupy every station to determine the inter-visibility of that station and the proposed one.

High poles are made of spruce and are 6x6 ins. x 100 ft., consisting of 3x6 in. by 20 ft. timbers bolted together and breaking joints every 10 ft. The pieces are laid out on the ground in exactly the position they occupy when in the air and marked piece for piece. The holes are bored for the bolts, the bolts put in place, and then removed. Cleats are nailed on one side of the pole, forming a support by which the observer climbs.

The first or lowest section of the pole consists of two widths of 3x6 in. bolted together making 6x6 ins. for a height of 20 ft., and a half member extending 10 ft. higher, the upper piece breaking joints with its opposite half. The first or lowest section is laid on the ground with its foot lashed to a stake, raised by ropes and pulleys, and steadied by guy wires. Attached to the top is a pulley block by which the next member is hoisted by ropes, bolted in place and properly guyed. This operation is repeated until the entire pole is raised. The pole can be laid out and raised in [illegible] a day; the horse and truck used in hauling the timber can be used for power raising. [illegible] man [illegible] the necessary force.

The field work under the direction of Mr. Mosman was begun October [illegible], 1904, and finished in the fall of 1905. The official report of the final results of the survey was received from Washington in December, 1905. It embodied the geographical positions of all stations, the azimuths and back azimuths of the lines, and the rectangular coordinates of the stations. Upon receipt of the report, the Topographical Bureau began the work of connecting the traverses with the stations and in many cases running new traverses connected directly with them. The Bronx official standard of length has been that of the Department of Public Parks. A comparison of this standard and that of the U. S. Coast and Geodetic Survey showed a difference of 0.01 ft. in 100 ft., so that in adjusting the traverses to the new survey, the lengths were first corrected for that difference, then started and closed on triangulation lines. The directions of many of the old fixtures, laid down and monumented, differed from the results of the coast survey. Where title had vested in streets and avenues, as well as where proceedings had been instituted, the physical lines had to be kept, and the dimensions and lengths as fixed by the triangulation simply played havoc with the final maps.

Imagine an error in direction of a certain line amounting to from 0 to 20", and the line as monumented to be kept, also a layout of streets at right angles to it, the fixtures at the other end of the streets being at right angles to another line where no error exists, and you will agree with me when I congratulate the other boroughs and tell them, they do not know what they have missed.

In general, traverses connecting the triangulation stations are called primary traverses. They are made with utmost care, every precaution being taken to exclude errors, the chaining being done in duplicate, and the two results should not differ more than 0.02 per 1,000 ft. The work should be done on cloudy days whenever possible.

In primary traverse work, the tape is not used level, but on slopes which are measured, a constant tension is maintained by the use of mechanical stretchers, the temperature is determined by thermometers attached to the tape itself, and the tape held by stakes or portable tripods.

The tapes are standardized exactly in the way they are used in the field, i. e., supported in the same way and with the same tension. Thus no correction is necessary for sag or tension.

For secondary traverses, the regular city engineer's 50 ft. spring balance tapes are used with plumb bobs and tacks in the ground for marking points.

TAPE STRETCHERS

The front tape stretcher consists of an upright hinged sideways at its lower end on a foot base and terminating at the top in a handle. On the upright travelling up and down is a block carrying the spring balance to regulate the tension. The tension is applied by a revolving bolt [illegible] in the block and operated by a lever attached to [illegible]. By means of the vertical motion of the block the balance and tape attached to it are raised or lowered, while the hinged motion of the upright gives lateral adjustment necessary for alignment. The rear stretcher is similar to that in front with the exception of the spring balance.

The advantages claimed for this stretcher system: that it is [illegible] with [illegible], that it is instrumental in producing more accurate work, because the tension can be maintained more easily and for a longer time than can be secured from other forms. The tension is [illegible] under control for almost any length of time. With the [illegible] relieved [illegible] the [illegible] [illegible] the tape from [illegible] length.

In the matter of [illegible] a number of [illegible] and [illegible] we [illegible] the [illegible] of the Engineer Regiment Armory. The tape stretchers were used in this work and they enabled us to observe [illegible] some differences [illegible] [illegible]. There were [illegible] tape [illegible] and the work [illegible] [illegible] [illegible]. [illegible] [illegible] [illegible] small difference was observed [illegible].

These tape stretchers are [illegible] in [illegible] and [illegible], in fact, they are indispensable.

PORTABLE TRIPODS

The portable supports are of iron with a round bar adjustable in length. The top of the bar is terminated by a rectangular cross piece forming a T shape with the bar. This cross piece forms the track on which slides a block which forms a support for the tape and adjusts to it, at a level with the tape, [illegible] the index mark which, by means of a tangent screw, is brought to coincide with the tape graduation. The block is set approximately near the tape graduation by sliding it along the bar and then clamping it. With the use of these tripods the driving of the projecting stakes is avoided, thereby effecting economy in time. You [illegible] encounter lines that do not permit of driving stakes, e. g., parks, lawns, pavements, etc. It is usually necessary to have the stakes or supports for tapes from 18 ins. to 30 ins. above the surface of the ground. In many cases this is impossible on account of the danger to travel as well as the annoyance of replacing if disturbed. They should have a cross section of 1x1 ins. to insure stability and should be well driven in the ground, which means that the staking [illegible] takes considerable time. These points, together with the impossibility of using them on pavements, rock formations, etc., give the portable tripods a decided advantage.

As to the use of plumb bobs you will get diverse expressions of opinion, but all will I think admit that plumb bobs have a proper place in the engineer's outfit. A mechanical test of a bob in a lathe does not prove [illegible] [illegible] [illegible] it make a bob [illegible] [illegible] accurate results. A [illegible] hole for the string and a [illegible] forming a shoulder on one side will destroy the accuracy of the best bob. The test of a bob is that the [illegible] through the center of [illegible] [illegible] [illegible] through the bob, [illegible] through the point. [illegible] a plumb bob [illegible] and [illegible] [illegible]. The [illegible] at the top [illegible] the string, if not [illegible] [illegible]. The hanging of the bob in the string [illegible] [illegible]. Every plumb bob used by the Topographical Bureau is tested and rejected if not found correct. Every time a tape [illegible] is [illegible] the plumb bobs used with it in the field are also tested.

Equal care is taken with the [illegible] [illegible] at least [illegible] [illegible] of [illegible] repetitions made being [illegible] and closing the horizon so that the closing reading shall be within at least 10 sec. of the [illegible]. These limits have been easily maintained under normal conditions, and reduce the traverse error to ¼ in. per mile, which is the minimum distance between the triangulation stations.

As an example, the distance between Parkway and Baychester was measured with our primary apparatus, the distance being 6,347.356 ft. Two measurements were made, differing by 0.01 ft. This measurement referred to triangulation station 6,204.25 vs. 6,204.37 U. S., a difference of 1 in 51,000.

The line was divided into five sections and was defined by monuments set before the measurements were made. The first section was measured three times, its length being 3,149.8185 ft. The greatest range being 0.0044 ft., or probable error of 1 in 4,500,000. A test record was kept of the time taken for measurement, 2,400 ft. taking 45 mins., a rate of 100 ft. in 2 mins.

On Tremont Ave., from Eastern Boulevard to Fort Schuyler Road, 8,000 ft. (over the line and back again) were measured in 5 hr. and 55 mins., a rate of 100 ft. in 4½ mins. Many obstacles presented themselves, much clearing being necessary. The line crossed the salt meadows and, the tide being up, the men had to pick their way over and around the streams. It was one of the worst places in The Bronx for this kind of work. The work being essential, was done with the primary apparatus and the results are given just as it was accomplished.

The line over the Eastchester Meadows was divided nearly equally by a large rock or boulder known as "Cactus Knoll." Each section was measured four times; the sections, as measured, are as follows:

EASTCHESTER LINE.

Cactus Knoll—Maguire.

1	6 688.5988 ft.	— 0.020
2	6 688.6035 ft.	— 0.015
3	6 688.6388 ft.	+ 0.020
4	6 688.6341 ft.	+ 0.015
Average	6 688.6188 ft.	

Cactus Knoll—Paul.

1	5 322.8185 ft.	+ 0.0110
2	5 322.8558 ft.	+ 0.0483
3	5 322.8056 ft.	— 0.0019
4	5 322.7501 ft.	— 0.0574
Average	5 322.8075 ft.	

making a total of 11,190.08 ft. as against 11,190.32 ft. as given by the triangulation, or a difference of one part in 46,600.

The monumented line of White Plains Road runs approximately parallel with this line over the Eastchester Meadows, being about 10,300 ft. distant. Cross-tie traverse lines connecting these two lines were run through 233rd St. and Gun Hill Road or 210th St., the distance between the last mentioned streets being about 6,000 ft. The error of closure was 0.012 per 1,000 ft. and the six angles gave an angular error of 0.7′ per angle. The total length of the traverse was 32,000 ft.

The line of Eastchester Meadows was measured with a 300-ft. tape (its cross-section being 3/32 x 1/50 in.), known as hoop skirt wire. The tape was supported every 50 ft., and the tension was 16 lbs.

The standardizing of this tape afforded an opportunity for studying the effects of temperature and forms of thermometers necessary with the different cross-sections of tapes.

A field comparator was established at the northeast corner of the ball ground at Crotona Park, and its length was determined by the applications six times of the Park Department 50-ft. standard length. This was done before sunrise to avoid the effects of the sun. The greatest range in these measurements was 0.003 ft. The 300 ft. was measured twice in the morning and three times after sundown. It was again measured at an interval of two weeks and found, by two measurements, to be correct. The thermometers used were the chemical thermometers, having no backing or support. They were graduated to single degrees, and estimated to ¼ degrees. Tests were continued from sunrise on, and soon it was certain that no reliable results could be obtained when the sun was shining. Another fact made itself manifest, which was that any kind of a thermometer would not answer for all tapes, and that certain thermometers would not answer at all. For instance, the thermometer of the so-called city engineer's tape is housed in a tube of brass which stores heat and renders the thermometer readings misleading. Any excess of metal or anything else which stores heat more than the tape does is bad. The comparator was advantageously located in a place that was shaded from the sun in the morning, and the proximity to the park caused alternately cool and warm currents of air about the tape. Thus it was impossible to note the tape lengths and the corresponding thermometer readings. The tape was first watched, and, at a noted change, the thermometer readings were simultaneously recorded. This was repeated several times and then the operation was reversed, *i. e.*, the thermometers were watched and the tape lengths recorded for the change noted in the thermometers. With the chemical thermometers, the corresponding changes tallied remarkably well, but with others this was not the case, and their use was discontinued. The cross-section of the tape regulates the sensitiveness required in the thermometers.

An interesting fact has been observed in the 300-ft. tape, which was that it was constantly increasing in length. The cause, we think, was its small cross-section for the 16-lb. tension. Greatest care had been taken in reeling and unreeling, so that its change in length could not have been due to that. The fact remains that it stretched, and Mr. Mosman, in his criticism, called attention to the possibility of change in length of the city chain. A low tension does not receive the endorsement of the U. S. Coast and Geodetic Survey. Our experience justifies the abandonment of small cross-sections and low tensions.

About a year ago some steel tapes were received from Keuffel & Esser, the cross-section was ¼ x 1/50 in., and the outer surface was tinned to avoid rusting. It was found that they did not respond to temperature changes the same as the steel tapes of the same cross-section. The explanation is that the surface, being bright, reflects some of the heat and does not, therefore, expand the same as the dull steel tape.

INVAR TAPES.

During the summer of 1906, four nickel steel tapes (Invar) were used with most satisfactory results by the U. S. Coast and Geodetic Survey on the measurement of six bases having an aggregate length of 60 km.

In the measurements of the bases referred to, three steel tapes were used at night, while the Invar tapes were used in daylight. Mr. French also states that the steel and Invar measures were computed independently. The differences between them are small, the largest being one in 300,000 and the average one in 500,000. The probable errors of the bases from the steel measured are more than double those from the Invar measures. The final probable errors of the bases, giving the Invar double weight, are between one in 2,500,000 and one in 5,000,000.

In 1900, the U. S. Coast and Geodetic Survey demonstrated that steel tapes gave the same accuracy as the bar apparatus with one-third of the cost. It is now shown that Invar tapes give results considerably more accurate and economical than steel tapes.

With mechanical stretchers for the front and rear of the tape, and portable tripods with adjustable heads to quickly and accurately hold the tape lengths, the error due to manipulation is reduced to nothing, and with the Invar tape, measurements can be made with no appreciable error.

SPRING BALANCES.

The spring balance used with the ctiy engineers' tape is faulty in respects other than that of the thermometer. It has, to my mind, a wrong construction. The level tube is at the handle end, *i. e.*, that further away from the tape and slides inside the thermometer tube. The thermometer tube being attached to the tape, takes a certain inclined position due to the catenary of the tape. This inclination must be secured every time the tape is used. For this position you rely on an inner tube which cannot be fitted close enough to insure parallelism without affecting the tension. The slightest movement out of parallelism affects the level and, therefore, the front and rear end of the tape. To my mind, the proper construction would be a reversion of the parts, *i. e.*, have the inner tube carrying the level immediately next to the tape, with plenty of play between the inner and outer tubes. The level tube being absolutely free from friction, would insure accuracy both of the level and tension.

A further suggestion would be to have the end graduations on the tape, and thus do away with the wear of the links between the tape and graduation on the handle.

The spring balance tapes, 50 ft. long, are inspected in a general way for tension, compensation scale, etc., when they come from the makers. Before they are taken in the field, they are tested for length. They are tested from time to time, at least every two months, to be sure they maintain their correctness. In the basement of the Municipal Building, The Bronx standard length is defined by fine cuts in copper bolts of 1 in. diameter, set 12 ins. deep in the granite cube. These are set in concrete forms 4 ft. square and from 3 ft. to 4 ft. deep, resting directly on solid bed rock. The mechanical stretchers are supported by sidewalls of the basement. A clutch, taking the place of the hand, receives the tape handles and is adjusted by mechanical means for elevation, side motion and tension.

Reference points for the long tapes are of similar construction. They are set in the ground at the northeast corner of the ball ground in the northerly corner of Crotona Park. The extreme distance between the monuments is 300 ft. with an intermediate one at 150 ft. The definition of the centers of the monuments are carried up by means of the vertical collimators.

There is now under construction, in the new buildings of the Department Yard at Webster Ave. and 181st St., a comparating room, 160 ft. long, for testing and standardizing tapes. Here the temperature will be regulated by a heating apparatus and thus provide for the determination of the coefficient of expansion as well as lengths at any desired temperatures.

Methods of base line measurements have been revolutionized within the last few years. Today, we have in the "Invar" tapes the greatest advance toward perfection in lineal measurements, far beyond the dreams of the most sanguine enthusiast.

Engineering-Contracting Monthly Review Index of Civil Engineering Literature.

A classified index and review of the civil engineering papers, articles, reports, pamphlets and books published during the month just passed is given in the succeeding pages. The literature indexed and reviewed—with the exception of books—relates solely to civil engineering. In the section devoted to Book Reviews all books in all branches of engineering are listed as received and such of them as seem worthy are reviewed as fully as due regard for conciseness will permit. In choosing books for review rigid selection is exercised. Next to careful choice of books for review timeliness of review is sought. All books are reviewed within a month of their receipt. The same statement is true of the articles and papers that are indexed. Also, as in choosing books for review the choice of articles and papers for indexing is based on merit. Numerical strength in "titles indexed" is not sought; excellence of selection is sought.

The purposes of the Monthly Review Index are: First, to inform civil engineers and contractors of the articles and papers of merit that are published each month, in such a way as will give a clear idea of their character and scope; second, to supply the user with the date and place of publication, the length of each article and the cost at which it can be secured. The name, adopted abbreviation, place of publication and price per number of each periodical examined for civil engineering articles are given in the list immediately following. The other information is given in the index proper for each article separately.

Books reviewed will be sent post paid on receipt of price by the Book Department of ENGINEERING-CONTRACTING; periodicals, etc., containing articles indexed should be ordered direct from the publishers.

LIST OF PERIODICALS INDEXED.

American Architect (Am Arch), New York, N. Y., w, 7x10 in., 15 cts
American Builders' Review (Am Bldrs Rev), San Francisco, Cal., m, 7x10 in.; 50 cts
American Carpenter and Builder (Am Car & Bldr), Chicago, Ill., New York, N. Y., m, 7x1[illegible] in., 20 cts.
American Engineer and R. R. Journal (Am Engr & R R Jl), [illegible] York, N. Y.; m; 7x10 in.; 2[illegible] cts
American Gas Light Journal (Am G L Jl), New York, N. Y., w, 10x13 in., 10 cts
American Institute of Electrical Engineers Proceedings (Am. I. of E. E. Proc.), New York, N. Y., m; 4x7 in., 50 cts.
American Machinist (Am. Mchst), New York, w, 7x10 in., 1[illegible] cts
American Society of Civil Engineers Proceedings (Am Soc C. E. Proc), New York, N. Y., m, 4x7 in., 75 cts.
American Society of Mechanical Engineers Journal (Am. Soc. M. E. Jl), New York, N. Y.; m, 4x7 in; 50 cts.
Annales des Ponts et Chaussees (An P & C), Paris, France; m
Applied Science, Toronto, Ont., m, 6x9 in., 20 cts
Architects and Builders Journal (Arch & Bldrs Jl), Baltimore, Md.; m; 9x12 in; 20 cts
Architects and Builders Magazine (Arch & Bldrs Mag), New York, N. Y., m, 5x8 in; 20 cts
Architect and Engineer of California (Arch & Engr), San Francisco, Cal.; m; 5x7 in; 15 cts.
International Railway Congress Bulletin (Int Ry Cong Bul.), Brussels, m; 50 cts.
California Journal of Technology (Cal Jl of Tech), Berkeley, Cal., m, 4x7 in.; 25 cts
Canadian Architect (Can Arch), Toronto, Ont., m, 7x19 in., 20 cts
Canadian Cement and Concrete Review (Can Cem & Conc Rev), Toronto, Ont
Canadian Engineer (Can Engr), Toronto, Ont., w, 7x11 in., [illegible]
Canadian Machinery and Manufacturing News (Can. Mach. & Mfg News), Toronto, Ont.; m, 7x10 in; 1[illegible] cts
Canadian Mining Journal (Can Min Jl), Toronto, Ont., bi-w, 7x10 in., 20 cts.
Canadian Municipal Journal (Can Mun Jl), Montreal, Que., m, 6¾x10 in., 10 cts.
Canadian Society of Civil Engineers Proceedings (Can Soc C. E. Proc.), Montreal, m, 4x7 in., [illegible] cts
Carpentry and Building (Carp & Bldg), New York, N. Y., m, 11x8 in., 10 cts
Cassier's Magazine (Cas Mag), New York, m, 5x8 in., 2[illegible] cts
Cement, New York, N. Y., bi-m, [illegible]x8 in., 2[illegible] cts.
Cement Age (Cem Age), New York, N. Y., m, 4x7 in., 10 cts
Cement and Engineering News (Cem & Eng News), Chicago, Ill., 7x1[illegible] in., 25 cts
Cement Era (Cem Era), Chicago, Ill., m, 7x10 in., 1[illegible] cts
Cement World (Cem Wld), Chicago, Ill., m, 9x11 in., 1[illegible] cts
Chemical Engineer (Chem Engr), Chicago, Ill.; m, 4x7 in., 1[illegible] cts
Clay Worker (Cl Wkr), Indianapolis, Ind.; m, 7x1[illegible] in., 2[illegible] cts
Compressed Air (Comp Air), New York, N. Y., m, [illegible]x7 in., 1[illegible] cts
Concrete, Detroit, Mich., m, 6x9 in., 1[illegible] cts
Concrete Age (Conc Age), Atlanta, Ga., m, 9x11 in., 10 cts
Concrete and Constructional Engineering (Conc & Constr Eng), London, England, m, [illegible]
Concrete Engineering (Conc Engr), Cleveland, O., m, [illegible] in., 10 cts
Contract News, [illegible]
Contractor (Contr), Chicago, Ill., bi-w, 7x10 in., 20 cts
Cornell Civil Engineer (Cor Civ Engr), Ithaca, N. Y., m, 4x7 in., 25 cts
Domestic Engineering (Dom Engr), Chicago, Ill., w, 6x9 in., 1[illegible] cts
Electrical Age (Elec Age), New York, N. Y., m, 7x1[illegible] in., 10 cts
Electrical Review (Elec Rev), New York, N. Y., [illegible]
Electric Railway Journal (Elec Ry Jl), New York, N. Y., w, 7x10 in.; 10 cts
Electrical World (Elec Wld), New York, N. Y., w, [illegible]
Electric Traction Weekly (Elec Trac Wkly), Chicago, Ill., w, 7x10 in.; 10 cts
Engineer (Engr Lon), London, England, w, [illegible]
Engineer (Engr), Chicago, Ill., bi-w, 7x11 in., 20 cts
Engineer (Eng), London, England, w, 8x11 in.
Engineers' Club of Philadelphia Proceedings (Engrs' Club Phila Proc), Philadelphia, [illegible], 4x7 in., 2[illegible] cts
Engineering-Contracting (Eng Contr), Chicago, w, 7x11 in., 1[illegible] cts
Engineering Digest (Eng Dig), New York, m, [illegible]x8 in., 2[illegible] cts
Engineering and Mining Journal (Eng & Min Jl), New York, w, 7x10 in; 15 cts
Engineering Magazine (Eng Mag), New York, m, [illegible] in., 2[illegible] cts
Engineering News (Eng News), New York, w, 8x11 in., 15 cts
Engineering Record (Eng Rec), New York, w, 8x11 in., 10 cts
Fire and Water Engineering (F & W Eng), New York, N. Y., 8x11 in., 1[illegible] cts
Le Genie Civil, Paris, France, w
Good Roads Magazine (Gd Rds Mag), New York, N. Y., m, 7x10 in.; 1[illegible] cts
Industrial Magazine (Ind. Mag), Cleveland, O., m; 4x7 in., 10 cts
Industrial World (Ind Wld), Pittsburg, Pa.; w, 7x1[illegible] in., 10 cts.
Insurance Engineering (Ins. Eng), New York, m, 4x6 in., 25 cts
Iron Age, New York, N. Y.; w, 7x11 in., 15 cts.
Iron Trade Review (Iron T. Rev), Cleveland, O.; w, 7x10 in., 15 cts.
Irrigation Age (Irr. Age), Chicago, Ill., m; 7x9 in., 10 cts
Journal Association of Engineering Societies (Jl Assoc Engr Soc), Boston, Mass.; m, 4x7 in., 3[illegible] cts
Journal Franklin Institute (Jl Frank Inst), Philadelphia, Pa., m, 4x7 in.; 5[illegible] cts.
Journal New England Waterworks Association (Jl N E W W Assn), Boston, Mass., q, 4x7 in
Journal Western Society of Engineers (Jl W Soc Engrs), Chicago, Ill., bi m, 4x7 in., [illegible]0 cts
Journal of Electricity, Power and Gas (Jl Elec, P & G), San Francisco, Cal., w, 7x10 in., 10 cts
Journal of Worcester Polytechnic Institute (Jl W P I), m, 4x7 in., 20 cts
Machinery, New York, N. Y., m, 7x11 in., 2[illegible] cts
Marine Review (Marine Rev), Cleveland, O., w, 7x1[illegible] in., 15 cts
Mines and Minerals (Mi & Mis), Scranton, Pa., w, 7x9 in., 20 cts
Mining and Scientific Press (Min & Sci P), San Francisco, Cal., w, 7x11 in., 1[illegible] cts
Mining Reporter (Min Rep), Denver, Colo., w, 7x10 in., 15 cts
Mining World (Min Wld), Chicago, Ill., w, 7x10 in., 1[illegible] cts
Modern Machinery (Mod Mchy), Chicago, Ill., m, 7x1[illegible] in., 10 cts
Municipal Journal and Engineer (Mun Jl & Eng), New York, N. Y., w, 7x10 in., 1[illegible] cts
Municipal Engineering Magazine (Mun Eng Mag), Indianapolis, Ind., m, 4x7 in., 2[illegible] cts
Ores and Metals (O & M), Denver, Colo., bi-w, 6x10 in., 1[illegible] cts
Pacific Building Engineer (Pac Bldg Engr), Seattle, Wash., w, 9x11 in., 1[illegible] cts
Popular Mechanics (Pop Mech), Chicago, Ill., m, [illegible]x7 in., 1[illegible] cts
The Polytechnic (Poly), Troy, N. Y., m, [illegible]
Power and Engineer (Pwr & Engr), New York, m, 7x1[illegible] in., 2[illegible] cts
Railway Age Gazette (R R Age Gaz), New York, w, 8x11 in., [illegible] cts
Railway Master Mechanic (Ry M M), Chicago, m, 7x1[illegible] in., 1[illegible] cts
Railway and Engineering Review (Ry & Eng Rev), Chicago, Ill., w, [illegible]
Railway and Locomotive Engineering (Ry & Loco Eng), New York, N. Y., m, 7x1[illegible] in., 2[illegible] cts
Railway and Marine World (Ry & M Wld), Toronto, Ont., m, [illegible]
Railway Engineering and Maintenance of Way (Ry Eng & M W), Chicago, Ill., m, [illegible]
[illegible] (R[illegible] & E[illegible]), Chicago, [illegible]
Rock Products (Rk Prod), Chicago, Ill., bi-w, [illegible]
[illegible], Ind., m, [illegible]
School of Mines Quarterly (Sch Mi Quart), New York, N. Y., [illegible]
[illegible], Zurich, w
[illegible] (Sci Am), New York, w, [illegible]
[illegible] Supplement (Sci Am Sup), New York, N. Y., w, [illegible]
[illegible] Journal of Engineering (Sib Jl Engr), Ithaca, N. Y., m, 4x[illegible] in., [illegible] cts
[illegible] Institute Indicator (Stev Inst Ind), Hoboken, N. J., m, 4x7 in., [illegible] cts
[illegible] Railway Bulletin (St Ry Bul), Boston, [illegible]
Surveyor (Surveyor), London, England, w, 6x11 in., 1[illegible] cts
Technology Quarterly (Tech Qr), Boston, q, 4x[illegible] in., [illegible] cts
U. S. Department of Agriculture Bulletin (Dept Agr Bul), Washington, D. C., 4x7 in.
U. S. Geological Survey Bulletin (Geo Surv Bul), Washington, D. C., 4x7 in.
Waterproofing and Fireproofing (W P & F P), Detroit, Mich., m, 7x10 in., 10 cts
Zeitschrift d. Oest. Ing. u. Arch. Ver., Vienna, w
Zeitschrift d. Ver. Deutscher Ing., Berlin, w

ROADS AND STREETS.

Road Treatment Work of the Massachusetts Metropolitan Park Commission in 1908.—Eng. Contr., May 19, 1909. 2-3 p.

Describes the work done by the Metropolitan Park Commission of Massachusetts in treating macadam roads with various tar and asphalt mixtures during the year 1908. The article is accomplished by a table giving a summary of costs of road repair and maintenance during the year named.

An Analysis of Traffic on Seven Typical Highways in Rhode Island.—By A. H. Blanchard, Eng.-Contr., May 12, 1909. 2 1-3 pp.

This article describes the methods employed in securing a traffic census on seven typical highways in Rhode Island. The classification of traffic that was adopted is explained and in five large tables are shown the results of the track census.

Tables for Use in Road and Street Work.—Eng.-Contr., May 5, 1909. 2-3 p.

The tables in this article give figures for determining areas of water ways for culverts, ordinates for crowning street pavement, weight of drain tile and cubic yards of broken stone per mile.

Steam Road Roller Maintenance.—Eng.-Contr., May 5, 1909. 1-6 p.

Gives the cost of maintaining 18 steam road rollers employed by the Massachusetts Highway Commission during 1908.

Experimental Road Work by the Massachusetts Highway Commission in 1908.—Eng.-Contr., May 5, 1909. 4 pp.

Describes at some length the experiment conducted by the Massachusetts Highway Commission to determine the best methods of constructing roads to prevent damage from automobile traffic.

The Theory of Economic Road and Street Design and Location.—Eng.-Contr., May 5, 12, 19 and 26, 1909. 4½ pp.

These are a continuation of the series of articles begun in the April 14 issue of the above journal. The articles start with the assumption that a scientific method of designing roads and streets is quite as possible as a scientific method of laying out a railway. The articles then present such a method giving rules and data of all kinds.

Controlling the Consistency of Bituminous Binders.—By C. N. Forrest, Eng. Rec., May 1, 1909. 1 p.

Describes and illustrates an instrument for determining the consistency of road binders and gives the results of some test made on a number of binders.

Experiments in Road Treatment in Massachusetts. Gd. Rds. Mag., May, 1909; 1½ pp.

Describes several experiments with bituminous binders conducted in 1908 by the Massachusetts Highway Commission.

New Road Legislation. Gd. Rds. Mag., May, 1909; 2 pp.

Gives an abstract of good road laws passed by the legislatures of Idaho, Georgia and North Dakota.

Street Cleaning Appliances. Mun. Jl. & Engr., May 19, 1909; 3 pp.

Illustrates and describes a number of street cleaning appliances, among them being the street flushing machines of Chicago, Ill., a hand flushing appliance at Buffalo, N. Y., and a suction cleaner used in California.

Standardizing Tests of Bituminous Materials. By W. W. Crosby, Gd. Rds. Mag., May, 1909; 1 p.

The article gives suggested tests and lines of investigation to be followed in determining the characteristics of bituminous material for highway work.

Illinois Experimental Roads. Gd. Rds. Mag., May, 1909; 3½ pp.

Gives detailed cost of experimental macadam roads constructed by the Illinois Highway Commission in 1906 and 1907.

The Future Road—the Wearing Surface. By Philip W. Henry. Gd. Rds. Mag., May, 1909; 2 pp.

A paper read at the International Road Congress in Paris, October, 1908. The article of road surfaces composed of bituminous cement.

Concrete Roadways. By Charles W. Ross. Gd. Rds. Mag., May, 1909; 6 pp.

In this article Mr. Ross has given his experience with concrete roadways. Various methods of mixing and placing the concrete are described. The paper was awarded second prize in the contest arranged by the Association of American Portland Cement Manufacturers. He also treats of the construction of curbing and street bridges, and gives some space to resurfacing macadam roadways with cement and sand.

The Road Conference. The Surveyor, May 7, 1909; 32 pp.

A brief account of the Road Conference held at the Institution of Civil Engineers. A number of papers were read at the conference and are reported in the above issue. Among the papers were the following: Notes on the Tonnage, Life and Wear of Stones in Road Surfaces, by John A. Brodie; Construction and Maintenance of Roads, Wear and Tear, etc., by William Nisbet Blair; Road Maintenance, by F. G. Carpenter; Construction and Maintenance of Roads, by Geo. A. Phillips; Width of Roads and Provision of Footpaths, by William Harpin; Wear and Tear of Motor Traffic on Roads, by W. J. Taylor; Construction and Maintenance of Roads, by Albert D. Greatorex; Effect of the Horseshoe and Narrow-Wheel Tire on Roads, by J. H. A. McDonald; Road Construction, Curves, Gradients and Camber, by H. T. Wakelam; Reducing Cost of Road Maintenance by Improved Construction of Roads, by Col. R. E. Carpenter.

Experiments in Road Treatment. Mun. Jl. & Engr., May 26, 1909; 2½ pp.

A description of experiments conducted by the U. S. Officer of Public Roads during 1908.

SEWERS.

Fundamental Principles of Sewage Purification on Land.—By Rudolph Hering. Eng. News, May 6, 1909. 3 pp.

This is a very interesting summary by a well known authority of the various principles of sewage purification which have come to be recognized by sanitary engineers. The subject is discussed under the heads of Bacterail Surface, Liquidity, Air Supply, Length of time of Percolation and Temperature.

Culvert and Sewer Design, with Especial Reference to Reinforced Concrete.—By Ernest M'Cullough, Eng.-Contr., May 5, 1909. 3 1-3 pp.

This article is a rather thorough discussion of the questions that arise in designing reinforced concrete sewers.

Some Novel Methods of Sewer and Street Construction on Reclaimed Land.—Eng.-Contr., May 5, 1909. 1 1-3 pp.

Describes the method of constructing sewers and also of constructing brick pavement on land which had been reclaimed by filling in with hydraulic dredges. The methods employed were unusually novel and interesting and the article will interest engineers who may have work of a similar character in hand. One feature of the pavement construction was that the concrete base was reinforced and was supported upon reinforced concrete beams carried by wood piles.

The Louisville Sewerage Improvements.—By Roger De L. French. Eng. Rec., May 1, 1909. 3 pp.

A description is given of a $4,000,000 sewer project. Methods of doing the work are described, and details of the work and design are illustrated with drawings and photographs.

Reinforced Concrete Block Sewer. By Stephen Litchfield, Mun. Jl. & Eng., May 5, 1909; 2½ pp.

Describes methods of construction and laying employed at Bath, Me.

Sewerage and Sewage Treatment in the United States. Mun. Jl. & Eng., May 5, 1909; 5 pp.

Tables containing data from a number of cities on methods of sewage treatment, methods of ventilating sewers, use of catch basins and amount and sizes of vitrified pipe and concrete sewers.

Septic Tank Patent Decision. Mun. Jl. & Eng., May 5, 1909; 1½ pp.

A discussion of the legal points of the Saratoga Springs decision in regard to the Cameron septic tank.

Sewage Treatment at Bloomington. By George L. Thon. Mun. Jl. & Eng., May 5, 1909; 3 pp.

Describes the sewage purification plant at Bloomington, Ind. Plant includes settling tanks, combined closing chambers and contact beds, percolating filters and sedimentation basin.

Concrete Sewers at Richmond, Ind. By Fred R. Charles, Mun. Jl. & Eng., May 5, 1909; 3 pp.

Gives the author's experience with reinforced pipe and monolithic reinforced concrete. Methods of construction and some cost data are given.

Sewage Disposal at Columbus, O. By E. A. Kemmler, Mun. Jl. & Eng., May 5, 1909; 10 pp.

A description of the sewage disposal system of Columbus, O. The system includes septic tanks and artificially constructed intermittent sand filters. The system cost about $675,000 and was placed in operation last fall. Numerous drawings and half-tones showing typical features of the plant are given.

The Influence of Rainfall on the Design of Sewers. By C. A. Battiscombe. The Surveyor, May 7, 1909; 2 pp.

Brings out a number of points regarding rainfall and the size of sewers.

Methods of Sewer Construction in Clinton, Ia. By Charles P. Chase. Mun. Eng. Mag., May, 1909; 4 pp.

Describes the construction of some four miles of concrete, brick and pipe sewer at Clinton, Ia. Some of the concrete was placed in freezing weather, and the instructions for doing this are given in this article. Approximate costs of the work are also given, as is a description of the plant employed.

WATER-WORKS AND HYDRAULICS.

Hydraulic Gate Valves for the Chicago Water-Works.—Eng. News, May 13, 1909. 1 p.

This article illustrates and describes the construction of a 42-in. hydraulic gate valve for the Chicago water-works.

General Specifications for the Design of Elevated Tanks and Stand Pipes.—By C. W. Birch-Nord, Eng.-Contr., May 12, 1909. 1 1-6 pp.

The author gives general specifications for the design of elevated tanks and stand pipes.

Discharge Formulas for Cast Iron Pipe.—By George L. Bean. Min. Scien. Press, May 8, 1909. 1 p.

A comparison is made of various pipe discharge formulas for clean cast iron pipe; the discharge in units of 1,000,000 gallons per 24 hours.

How to Find Leakage in Water Mains and Sewers. Mun. Eng. Mag., May, 1909; 4 pp.

Describes methods of finding leakage in mains, valves and hydrants, in services and in houses.

Cost of Concrete Pipe. Mun. Jl. & Engr., May 5, 1909; ½ p.

Table showing the nature and cost of concrete pipe of various sizes, thickness, etc., in a number of cities.

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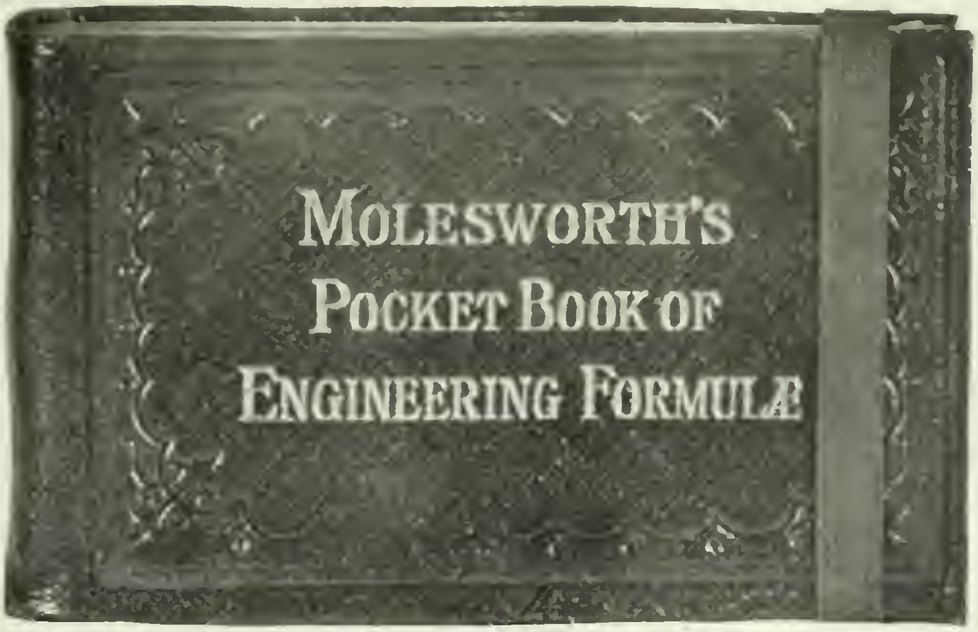

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The Hennepin Power House of the St. Anthony Falls Water Power Co. By R. [illegible] Thomas. Eng. Rec. May [illegible] 1909. [illegible] p.

A general article on the power development showing drawings and photographs to illustrate it.

The Practical Sterilization of Water and of Sewage Effluents. By H. [illegible] H. [illegible]. The Surveyor, May 7 and May 14, 1909.

In this paper the Author deals with the practical sterilization of sewage effluents and of water as distinguished from the theoretical side of the question.

DRAINAGE AND IRRIGATION

Opinions of Foreign Engineers on the Value of Forests for Preventing Erosion. Eng. News, May 6, 1909. 1 p.

This article quotes the opinion of a number of foreign engineers on the question whether forests [illegible] action in preventing steep [illegible] slopes from erosion.

Cost of Constructing a Wood Flume 4,3[illegible]3 Feet Long, Klamath Irrigation Project. Eng. Contr. May 26, 1909. [illegible] p.

Gives the detailed cost of constructing a flume [illegible] ft. long having [illegible] of [illegible] ft.

RIVERS, HARBORS AND CANALS.

Lock No. 3 Cumberland River. By William W. Harts. Eng. News, May 6, 1909. 2-3 p.

This article describes [illegible] construction of the masonry lock and [illegible] dam and gives complete costs of the work.

The Waterways of the United States. Ac-

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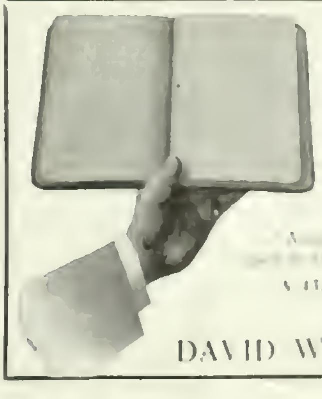

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tual Expenditures and Results to Navigation and Commerce.—By Alexander H. Weber. Eng. News, May 6, 1909. 1 2-3 pp.

This is a very interesting statistical summary of the expenditures which have been made in improving the waterways of the United States. The improvement work is divided into several classes and the expenditure for each class is summarized. Figures are also given for each class showing as far as possible the benefits to commerce which have been derived from the expenditure.

River Bank Protection in Northern India by Stone-Filled Wire Net Cylinders.—Eng. News, May 6, 1909. 1½ pp.

An article describing the methods of river bank protection employed in India on rivers which are subject to sudden and excessive floods. The point of chief novelty in the work is the use of cylinders of wire netting which are filled with small boulders with which to construct revetment spur dams and other similar structures.

The Design of Cable Stations for River Measurements.—By J. C. Stevens. Eng. News, May 6, 1909. 2 pp.

This article discusses in great detail the methods to be followed in designing cable stations for river measurements. Stations of this kind have been constructed and are being constructed in considerable numbers by the Water Resources Branch of the U. S. Geological Survey.

Some Methods and Costs of Revetment and Dam Work, Rock Chiseling and Submarine Drilling and of Cofferdam Work; Upper Mississippi River Improvement.—By C. McD. Townsend. Eng.-Contr., May 12, 1909. 5 pp.

Describes in detail many of the methods used in these various classes of work. Also gives some costs. Illustrated with drawings. Condensed from a paper presented to the Western Society of Engineers.

New Municipal Piers in Baltimore Harbor.—Eng. Rec., May 8, 1909. 3 pp.

An important article on pier work, as it not only describes the old timber bulkheads, so extensively used in America, but also a radical departure in pier work, consisting of a concrete structure on concrete piles. Methods of doing the work are also described.

The Construction of a Spillway on the Tombigbee River.—Eng. Rec., May 22, 1909. 2 pp.

In this article is described the foundation work, including a description of a floating concrete mixing plant.

RAILWAYS.

Temporary Work on the Canadian Pacific Railway.—By J. Grant MacGregor, Can. Engr., May 14, 1909. 5 pp.

The author describes and illustrates in detail a number of types of structures which have been used for temporary work on the Canadian Pacific Railway. The structures described compromise cattle guards, culverts, trestles, crib piers and abutments, and crib retaining walls. Nearly all these structures are of wood. Some general costs of the work are given.

Screw Spikes and Improvements in Rail Fastenings.—Eng. News, May 29, 1909. 2 2-3 pp.

This is a reprint of an article by Mr. W. C. Cushing of the Pennsylvania System on the use of screw spikes for fastening rails. The European practice is described at some length and the subject of screw spike fastenings is discussed in detail.

Methods of Snow-Fighting on Railroads.—By A. W. Wheatley. Eng.-Contr., May 26, 1909. 1½ pp.

A very interesting article describing the methods employed in keeping railway track clear of snow. The handling and operation of a rotary snow plow are described in great detail. This article contains many hints which should be found useful by any railway operating official who has a large amount of snow fighting to do.

Methods and Cost of Making 2,000 Miles of Preliminary and Location Surveys for a Railway.—Eng.-Contr., May 19, 1909. 5 pp.

This is an unusually interesting article to railroad locating engineers. It describes the methods of making 2,000 miles of preliminary and location surveys for a railway in the south central states. The various blanks, forms and standard titles used are illustrated and the cost of the several surveys is given in detail.

The Method of Appraising the Land Value of the Michigan Railways.—Eng.-Contr., May 5, 1909, 1 p.

Two letters describing the methods employed in appraising land values in the work of the Michigan railroad appraisal.

The Detailed Cost of Elevated Railways in Brooklyn and New York.—Eng.-Contr., May 5, 1909. 1 p.

Gives in tabular form the cost of constructing double track elevated railways in Brooklyn and New York during three different periods ranging from 1885 to 1903.

Steel Ties vs. the Wooden Tie.—Ry. & Eng. Rev., May 8, 1909. 1 p.

A letter to the editor giving some estimates of the relative cost of steel and wooden ties.

Standard Telegraph and Telephone Lines of the Virginian Ry.—Ry. & Eng. Rev., May 8, 1909. 1 p.

A short description is given of the standard plans, and the details are shown by drawings.

Railway Rate Making Practice.—By Wm. Z. Ripley, R. R. Age Gaz., May 7 and 14, 1909. 7 pp.

A discussion of rate making practices in use today, covering the evolution of a rate sheet and the exigencies of railway competition.

Sudbury-Kleinburg Branch of the Canadian Pacific.—By F. S. Darling. R. R. Age Gaz., May 14, 1909. 4 pp.

A description is given of this branch line and the need of it, also of the work of construction. Illustrated with maps and photographs.

Replacing a Double-Track Skew Bridge and Viaduct.—Eng. Rec., May 8, 1909. 2 pp.

Describes the method of replacing a bridge of this character on the Lehigh Valley R. R., without interfering with the traffic.

Suggestion in Regard to Earth Shrinkage and Overhaul, and the Use of Graders and Steam Shovels on Railways.—By F. Pardoe Wilson. Eng.-Contr., May 5, 1909. 3 pp.

A very interesting paper suggesting for discussion various phases of the shrinkage of earth in railroad embankments, the overhaul of material, the laying out of wagon road crossings, and the use of elevating grades and steam shovels for railroad grading.

Instrument for Measuring the Wear of Rails.—By Wilhelm Eyberger. Bul. Inter. Ry. Con. May, 1909. 1½ pp.

Describes a very simple but ingenious instrument for measuring the wear of T rails.

Comparative Rail Specifications.—R. R. Age Gaz. May 21, 1909. 6 pp.

In five columns, running across two pages of the paper, are given the rail specifications of the American Railway, the Steel Manufacturers of America, the American Society of Civil Engineers, the American Railway Engineering and Maintenance of Way Association and the American Society for Testing Materials. A sixth column is reserved for comments. This arrangement admits of ready comparisons being made.

Mechanical Appliances for Track-Laying.—By J. F. Springer. Cas. Mag., June, 1909; 16 pp.

Track-laying machines are described in this article and also the method of operating them. Illustrated with a large number of photographs.

Track Elevation in Chicago.—Eng. Rec., May 29, 1909; 3½ pp.

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The Failure to Secure an Illinois Water-Way Law.

Legislation to provide for an Illinois state waterway has failed. The state legislature has adjourned without passing either of the measures designed to make a beginning in the long sought [illegible] from the Great Lakes to the Gulf of Mexico. The [illegible] of this failure [illegible] [illegible] in the [illegible] [illegible] [illegible] [illegible] the [illegible]. [illegible] was [illegible] and to what extent [illegible] [illegible] by [illegible] we do not propose to discuss here. The fact is that for two years [illegible] [illegible], nothing [illegible] [illegible] the expressed intention of the people of Illinois that the State shall construct a deep waterway from Chicago to the Illinois River. Both engineers and contractors are particularly concerned in this fact, in that, first, they have to a [illegible] so far [illegible] failed to bring about a different result, and, second, they have the opportunity before them of redeeming this [illegible] in a manner which we shall outline further on.

The first legislative step toward the [illegible] state waterway was taken in October, 1907, when by concurrent vote of both houses of the Illinois general assembly an amendment of the state constitution providing specifically for an issue of $20,000,000 of bonds to build a waterway from Lockport to near Utica, Ill., was ordered submitted to popular vote. Lockport is the present terminus of the Chicago Drainage Canal and Utica is on the Illinois River, and the distance between them by canal route is 62 miles. At the general election in 1908 the people voted on this amendment and of the 1,151,067 votes cast at this election 58.56 per cent were for the amendment, and 16.75 per cent were against it; 24.69 per cent of the voters were too indifferent to express their will by vote. A majority, it was so seen, of the voters favored the amendment and, accordingly, the policy of a state-built waterway.

Antedating the election a commission known as the Internal Improvement Commission of Illinois had been appointed and had been at work studying the engineering and other features of the proposed canal. This commission made a preliminary report in the fall of 1908 which formed the [illegible] the information on which the people based their votes. The main features of this report were published in ENGINEERING-CONTRACTING of Oct. 14, 1908. Later studies modified the original plans somewhat. As the plans now are it is proposed: After leaving the Chicago Drainage Canal, which is 160 ft. wide, to construct a channel 200 ft. wide, wherever it must be artificially created, with a depth of [illegible] ft. and north of [illegible] 14 ft., to construct the locks 600 ft. long and 80 ft. wide, with a depth of 24 ft. of water over the [illegible]. The cost of this canal including [illegible] and water power plants capable of developing [illegible] h.p., it was estimated, would be within the appropriation of $20,000,000. [illegible] [illegible] made [illegible] Mr. Isham Randolph, M. Am. Soc. C. E., who had built the Chicago Drainage Canal, [illegible] chief engineer.

Shortly after the Illinois general assembly of 1909 had convened a bill based on [illegible] of the Internal Improvement Commission and embodying the [illegible] for the proposed waterway was introduced. This bill met opposition from another faction of those interested in waterway construction. The opposing faction, [illegible] the plans of the Internal Improvement Commission, [illegible] [illegible] [illegible] [illegible] the government to complete the deeper channel through to the Gulf. In furtherance of its views this opposing faction [illegible] [illegible] Federal legislation. It is unnecessary now to relate how the [illegible] [illegible] between the two factions. The fact is that though the Internal Improvement Commission's bill passed the [illegible] [illegible] [illegible] [illegible]. So the matter stands now.

The hope of any further action before 1911 [illegible] [illegible] legislature. [illegible] [illegible] [illegible] toward the desired legislation. [illegible] [illegible] [illegible]. It should be the aim of all [illegible] to see an Illinois waterway [illegible] the engineers and the contractors.

An Engineering Commission.

An act providing for a commission for [illegible] the building laws of Illinois will come before the next General Assembly for action. In order that this act may receive proper consideration and that due regard may be given to the engineering interests concerned the Western Society of Engineers has appointed a committee to work with the legislature having the act in charge and has voted the following resolution:

> Be it Resolved, That the Western Society of Engineers recommends that the Commission to be appointed for the above purpose should include one member from the Western Society of Engineers and one from each of the following national engineering societies: The American Society of Civil Engineers, The American Society of Mechanical Engineers and the American Institute of Electrical Engineers; and requests that the [illegible] [illegible] and the [illegible] of [illegible] on the Commission to be so [illegible] [illegible].

Engineers should [illegible] [illegible] this committee [illegible] [illegible].

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Concrete and Reinforced Concrete Section

Note:—This section is devoted to methods and cost of constructing concrete and reinforced concrete structures. It will cover the selection, testing and proportioning of concrete materials; laboratory tests of concrete; concrete mixing, transportation and placing; fabrication and placing of reinforcement, and form construction and erection. It will also contain articles on new and interesting developments in the design of reinforced concrete.

Hints for Inspectors of Concrete Work.

VII.

Molding and Driving Concrete Piles.

Concrete piles are constructed by two methods: (1) A hole is formed in the ground by driving a metal pile or by other means and is filled with concrete; (2) a concrete pile is cast in molds and after it has become hard is driven like a timber pile. The various methods of molding piles in place are controlled by patents and pile construction by these methods is done only by certain firms. Cast piles of certain special forms are also patented, but if these special forms be excepted, cast piles may be made and driven by anyone. In piles molded in place the chief uncertainties are whether the concrete is properly placed and tamped and remains uninjured until it has hardened and gained its strength. With cast piles the uncertainty is whether the pile after driving is still sound or has been injured by the driving. These uncertain points are the chief ones to be watched out for by the inspector.

Driving Piles In Place.—See that the driving of shells or cores for new piles does not injure adjacent piles which have been concreted but in which the concrete is still fresh or green. The jar in driving is considerable in certain kinds of ground and may readily endanger the setting and hardening of adjacent concrete work. When piles are close driven the formation of the new holes may also so compress and shift the surrounding soil as to constrict or distort fresh concrete which has been placed in adjacent holes previously formed.

Constructing Piles In Place.—See that the concrete is deposited with care to prevent seggregation of stone from mortar and to prevent admixture of dirt with the concrete. A strong, dense concrete is needed for piles and the usual precautions for securing it should be observed.

Reinforcing Piles in Place.—See that the reinforcement is set parallel and concentric with the axis of the pile. The best practice is to assemble the reinforcement into a unit frame and to place it as a unit.

Cast Piles.—See that cast piles are straight, that the metal points, if such are used, are firmly attached, that there are no cracks, that the surface is not deeply chipped and that none of the reinforcing metal is exposed. If cored for sinking by water jet see that the cores are open and unobstructed; if fluted on the sides to provide passages for rise of water used in jetting see that the flutes or corrugations are not obstructed.

Molds for Cast Piles.—See that the molds are constructed straight and are kept level and true to line. Surface roughness joint marks, etc., are not objectionable, but a pile which is not straight is liable to fracture in driving or under load. See that the molds are supported by a rigid level foundation or molding bed.

Reinforcing Cast Piles.—See that the reinforcement is set parallel to and concentric with the axis of the mold, and is held rigidly in this position during concreting. The best practice is to assemble and wire the reinforcement into unit frames for placing.

Casting Piles in Tiers.—See that independent supports are provided for each tier of molds in casting piles in tiers to save room.

Concreting Cast Piles.—See that the concrete is poured at several points along the mold; concrete which is all poured at one point and made to fill the mold by flowing is likely to be streaky.

Driving Cast Piles.—See that the driving of cast piles is so done that the pile is not fractured in the body. See that the head is protected by a cushion cap to take the direct blow of the hammer. Watch the driving carefully to discover cracks, excessive spalling, etc. If the driving is done by water jet see that the pile is settled to a firm bearing.

Handling Cast Piles.—See that the method of handling the piles to the driver is such that damaging strain is not brought on the pile. Cast piles may be cracked by roughly dragging them with one end on the ground or by swinging them clear by a fastening at mid-length.

Cast Concrete Work.

Cast concrete work comprises hollow building blocks, lintles, beams, columns, or other molded members, and ornamental shapes. The blocks, etc., are produced by pouring, tamping or compressing concrete into molds and permitting it to harden to the molded shape. The casting or molding is commonly done in factories when the inspection relates usually to the finished block alone, but sometimes it is done on the work when the inspection relates to methods of manufacture as well as to the finished product. The methods of molding and hardening are so many that only general directions for inspection can be given: for special variations in process the inspector must devise in addition rules to fit the particular characteristics of the work in hand.

Methods of Molding.—Three general processes are employed for molding cast concrete work: (1) A dry mixture is heavily tamped into a mold and the block is immediately released and set aside for curing; (2) a liquid mixture is poured into molds where the blocks remain until hard; (3) a medium wet mixture is compressed into molds by hydraulic presses or other means of securing great pressure.

Mixing for Dry Mixture Blocks.—See that the mixing is thorough and uniform. The amount of water used for dry mixture blocks is so small that it can be evenly distributed through the material only by careful and thorough mixing.

Consistency of Dry Mixtures.—See that the mixture is as wet as can be used without sticking to the molds and without sagging or sloughing when the molds are removed. The proper consistency has to be determined by experimenting on the materials being used. The block should part from the molds without sticking and should preserve its molded form perfectly.

Size of Dry Mixture Batches.—See that the size of batch mixed is not greater in amount than the quantity that can be molded into blocks before the cement begins to set.

Molds for Dry Mixture Blocks.—See that the molds are rigid and are rigidly bolted, clamped or locked together. See that the molds are so constructed that they can be removed or "released" without injury to the green blocks. See that the platens or working plates on which the block is carried and stacked are stiff enough not to spring under the load and can be gotten hold of for carrying without wrenching or tilting the green block.

Tamping Dry Mixtures.—See that the tamping is done from the bottom up as the mixture is filled into the mold. See that the tamping is thorough, that the material is thoroughly compacted in corners and around edges as well as in the center of the blocks. Do not permit the mold to be half filled before beginning tamping, fill the mold a little at a time and continue tamping from the first shovelful until the mold is filled. Unless the tamping is even and uniform there will be soft spots in the block.

Facing Dry Mixture Blocks.—See that the facing mixture is well bonded with the concrete backing by tamping the two together. The common practice is to place the facing mixture against the bottom or sides of the mold and fill above or behind with the concrete backing, which is tamped as the filling proceeds.

Removing Dry Mixture Blocks From Molds.—See that the block is removed from the mold to the curing skids without cracking it or injuring corners or arrises. A dry mixture block when taken from the mold has no cohesion except the tamping density; it has to be removed and handled with great care to prevent injury. Arrises and corners, if not badly damaged, can be repaired, but a block which is cracked cannot be satisfactorily repaired; it should be broken up and the material thrown back and molded over.

Stacking Dry Mixture Blocks.—See that the green blocks are stacked for curing in a horizontal position on unyielding supports and so as not to touch or to bring any weight on adjacent blocks.

Protecting Dry Mixture Blocks.—See that blocks are molded and stored for curing so that they cannot be acted upon by direct rays of the sun, warm air currents or frost. A shed or housing should be provided for both molding and storing, and the molded blocks had better remain under cover for at least a week. If shed room cannot be provided for a week's output of blocks, the blocks may be carried outside after setting and covered with canvass, straw or other covering that will preserve the moisture and shield the blocks from the sun and wind.

Sprinkling Dry Mixture Blocks.—See that the blocks are freely supplied with water by sprinkling. A dry mixture block does not have enough mixing water to enable the cement to set and harden perfectly and this deficiency has to be supplied by sprinkling. The sprinkling should begin as soon as the cement is hard enough not to wash, within an hour after molding, and should continue for at least ten days. See that the sprinkling, particularly while the block is still soft, is done by means of a gentle spray which will not "wash" the concrete.

Removing Dry Molded Blocks from Platens.—See that the block is removed from the slates by inverting or tapping it onto a smooth surface and then the pattern is loosened by tapping it lightly and not by wrenching or prying. Generally the patterns are removed at the end of about 24 hours and the slates are laid away and kept moist.

Curing Period for Cast Stone Blocks.—See that the blocks are cured for at least 10 days before they are removed from the storage yard for use in construction.

Filling the Molds.—See that the mixture is thoroughly stirred and conveyed to the molds so as to prevent separation and is compactly rammed and edges tamped. The mold may be filled in one pouring if size permits and if two or more batches are required for filling see that the pouring is as nearly continuous as practicable.

Removing Molds from Cast Members.—See that the mold is not removed until the concrete has thoroughly set and is strong enough to do without the support of the mold. The time of safe removal depends on the nature of the molded piece, its size, shape, weight and the strains which will come upon it in the process of removing the forms. A small compact block can be turned out of the molds as soon as the cement has set if care is used; a heavy molded girder can have the sides of the mold removed in 12 to 24 hours but it cannot be handled for a much longer period depending on conditions.

Provision for Handling Molded Blocks.—See that, in molding heavy blocks, suitable provision is made for handling by molding dog and clevis holes in the block, inserting pins or eye bolts, etc. See that these holes or fastenings are liberal in size and are not located too near corners or faces, else the strain of lifting will shell off the concrete.

Accuracy of Shape and Dimension.—See that the block is true to shape and exact in dimensions, with faces true to plane and edges true to line. See that moldings and other ornamentations are perfect. A molded block should be equal in perfection to cut stone in all particulars of shape and dimensions.

Vice Consul-General Willard B. Hull, writing from Canton, gives the following account of the establishment of extensive works by the Chinese government for the manufacture of building supplies. The institution, which is known as the Chinese Government Cement Works, will have a daily output of 500 barrels, each barrel weighing 375 pounds net. The cement will be manufactured at a cost of about $1.15 a barrel, and they expect to put it on the market at $5 Mexican a barrel (cheaper gold). This is 23 cents a barrel cheaper than the Green Island cement made in Hongkong, but it is thought that [illegible] keen the Chinese will reduce their price considerably, as they expect to be able to manufacture the cement at a lower figure than it can be manufactured in Hongkong.

Methods and Cost of Building a Concrete Culvert in Freezing Weather.

The following account of concrete culvert construction with data on costs is taken from information published by Mr. J. H. Ryckman in the "Engineering Record" for April 17, 1909. The culvert was built by J. P. Mullarkey at Montreal, P. Q., by contract, during December, 1908. It contained 241 cu. yds. of concrete and was of the section and dimensions shown by Fig. 1.

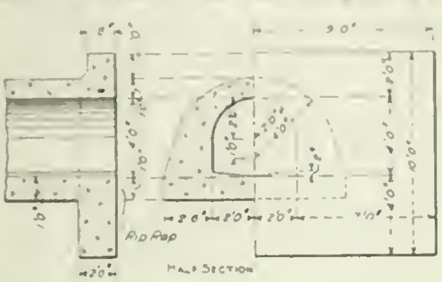


Fig. 1—Details of Concrete Culvert.

The concrete was a 1:2½:5 mixture up to the springing line and a 1:2:4 mixture for the arch ring; the aggregate was pit gravel running very uniform and containing a maximum stone of 1½ ins. It was screened at the pit through a ½-in. screen and the screenings were remixed with equal parts of gravel direct from the pit, the mixture giving the required 30 per cent of sand. The gravel was delivered in dump carts to the top of the bank above the work and from there it was chuted to the mixing board as wanted.

The mixing was done by hand and the mixed concrete was delivered to the work in steel wheelbarrows by means of a runway on the forms, Fig. 2. A very dry mixture was used to reduce chances of freezing. A gang of 8 men mixing and wheeling averaged 10½ cu. yds. mixed and placed per shift. The footing course was first concreted and then the forms were erected. The arch center and the outside lagging up to the springing line level were placed and the sides were concreted, then the remainder of the outside lagging was placed and the arch ring was concreted. The concreting was continuous, work being carried on night and day. The forms used are shown by Fig. 2. The lagging for the inside form was dressed lumber and dressed lumber was used for lagging the outside forms for a short distance at each end; all other lagging was rough lumber. The outside forms were made as shown instead of circular to economize labor; the top of the arch ring between forms was rounded by shovel, the correct height at the crown being fixed by the vertical board shown by Fig. 2.

The provisions against frost consisted of heating the gravel and the mixing water and of covering the fresh concrete. The water was heated in large iron pots. The gravel was heated by building large wood fires on top of the stock pile. Some of the heat was lost in chuting the gravel to the mixing board, but this chuting permitted most of the ashes from the wood fire being blown away by the wind. With the aid of the hot water the concrete was still warm when deposited. As soon as deposited the concrete was covered with cement bags, and when a 4-ft. length of arch ring had been completed it was covered with cement bags and about a foot of loose straw. Though the temperature ranged from freezing to below zero, no trouble was had because of frozen concrete.

The cost of construction, partly actual and partly estimated, was as follows:

Concrete:

	Total.	Per Cu. Yd.
Cement, [illegible] bbls. at $[illegible]	$[illegible]	$[illegible]
Cement storage	[illegible]	[illegible]
Cement hauling to site	[illegible]	[illegible]
Total cement	$[illegible]	$[illegible]
Gravel, Excavating and Heating:		
[illegible]	$[illegible]	$[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
Total gravel	$124	$[illegible]
[illegible]		
[illegible]	$[illegible]	$[illegible]
[illegible]	[illegible]	[illegible]
Total [illegible]	$[illegible]	$[illegible]
Grand total	$[illegible]	$[illegible]
Forms, Materials:		
[illegible] ft. B. M. [illegible] at $[illegible]	$[illegible]	$[illegible]
[illegible] ft. B. M. [illegible] at $[illegible]	[illegible]	[illegible]
[illegible] ft. B. M. [illegible] at $[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible] at $[illegible]	[illegible]	[illegible]
Total material	$[illegible]	$[illegible]
Labor:		
[illegible]	$[illegible]	$[illegible]
[illegible]	[illegible]	[illegible]
Total labor	$[illegible]	$[illegible]
Grand total	$[illegible]	$[illegible]
Salvage value	$[illegible]	$[illegible]
Net cost	$[illegible]	$[illegible]

This high salvage value allowed the forms was justified by the fact that they could be used again for other culverts on the same line of railway. The salvage value is the total cost less 10 per cent depreciation and estimated expense of taking down, transporting and re-erecting on new work.

Summarizing the above figures and adding general and other expenses we have the following:

	Total.	Per Cu. Yd.
Superintendence, office, etc.	$[illegible]	$[illegible]
Int. and Dep. on plant and tools	[illegible]	[illegible]
Platform, runways, etc., less salvage	[illegible]	[illegible]
Forms	[illegible]	[illegible]
Materials	[illegible]	[illegible]
Labor	[illegible]	[illegible]
Totals	$[illegible]	$[illegible]

Smoke prevention will be discussed at the fourth annual convention at Syracuse, N. Y., on June 23, 24 and 25, of the International Association for the Prevention of Smoke in the following formal program: "Smoke Abatement in Chicago," by Paul

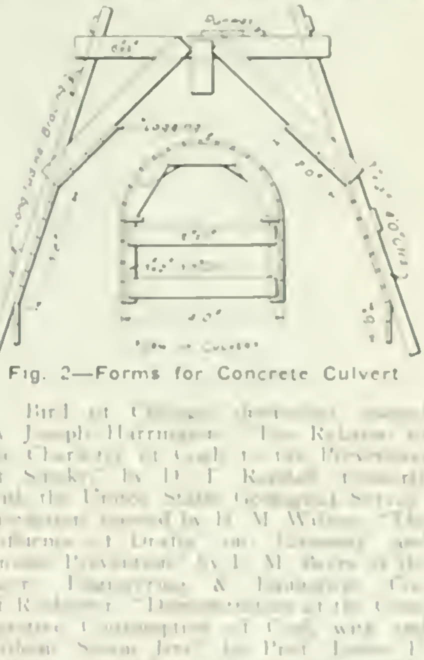


Fig. 2—Forms for Concrete Culvert

P. Bird of Chicago, discussion opened by Joseph Harrington; "The Relation of the Character of Coal to the Prevention of Smoke," by D. T. Randall, connected with the United States Geological Survey, discussion opened by H. M. Wilson; "The Influence of Drafts on Economy and Smoke Prevention," by [illegible] of the [illegible] Engineering & [illegible] Co. [illegible]; "Determinations of the Comparative Consumption of Coal, with and without Steam Jets," by Prof. [illegible] of Syracuse University; "The Elimination of Industrial Smoke," by [illegible] of the Power Specialty Company of New York city; "Fuel Economy and Smoke Prevention," by H. M. Wilson, Chief Engineer, United States Geological Survey; "The Smokeless Furnace," by S. B. Flagg, Engineer, U. S. Geological Survey; "The Legal Aspect of Smoke Prevention," by D. Raymond Cobb, of Syracuse.

Earth and Rock Section

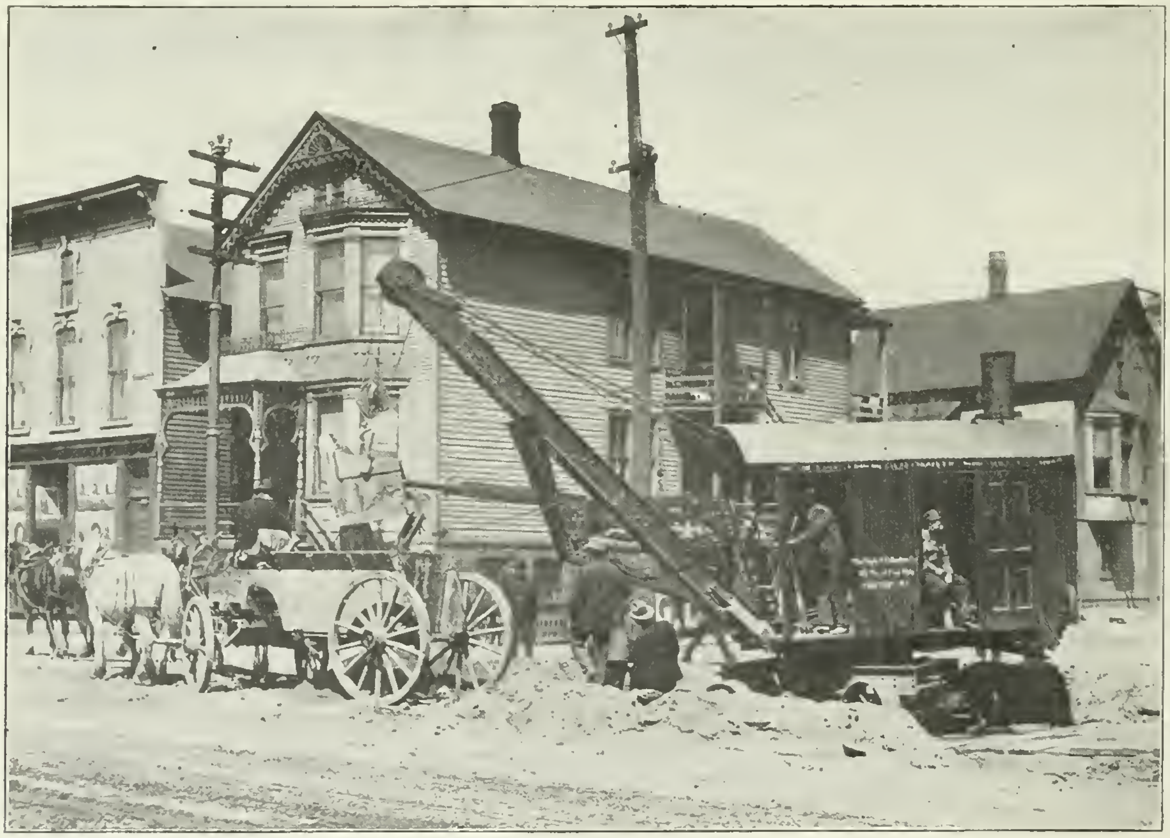
Note: This Section is devoted to methods and costs of excavating earth and rock and building embankments. It will cover the grading of roads and railroads, diking and canal work, dredging, building reservoirs and earth dams, sewer and water pipe trenching, quarrying, etc.

Excavating Street for New Pavement with a Revolving Steam Shovel.

Some 16,000 to 20,000 cu. yds. of excavation in cut ranging from 14 to 18 ins. in depth is being done by steam shovel in repaving a portion of Wentworth Ave., in the city of Chicago. The excavation is being made between curb and street railway track on each side of the avenue, the strips being approximately 17 ft. wide each. The excavation is being made for a granite block pavement on a 6-in. concrete base. The Ready & Callaghan Coal Co., Chicago, Ill., are the contractors, and they are using a No. 0 Thew steam shovel, made by The Thew Automatic Shovel Co., Lorain, O., for the work.

The accompanying illustration shows the shovel at work and indicates clearly the shallow depth of the cut. The shovel is of the traction type and travels on a track of short pieces of 3-in. plank which are pulled out from behind and laid ahead as the shovel advances. These tracks rest on a layer of planks laid on the bottom of the cut and across-cut; these planks are also pulled out from behind and placed ahead as the work advances so that the plankway is never more than a few feet longer than the wheel base of the traction trucks. On the Wentworth Avenue work 4 men are employed keeping the brick laid. In addition to the 4 pitmen, 2 men are required to keep the adjoining street railway rails clear of earth; cars pass at about 1 minute intervals during the day.

The shovel loads directly into wagons, as shown by the illustration and has to wait on the wagons. This limits its output which, however, runs from 150 to 300 cu. yds. excavated and loaded per 8-hour day. The shovel is operated by a shovelman and a fireman and there is required a snatch team and driver to help the wagons out of the pit at times, to snake away crosswalk stones, etc. Altogether the working gang employed at the shovel is 8 men. Were there no street car traffic to interfere this gang could be reduced by 2 or possibly 3 men. About 1 ton of coal is burned per day.



Revolving Steam Shovel Excavating a 14-in. Cut for Pavement Foundation.

The success of the shovel in this work is due to two principal features of its construction: (1) the full circle revolution and (2) the horizontal crowding motion of the dipper. The full circle revolution permits the dipper to take a cut at any point in the circle and to deliver its load at any other point, while the horizontal crowding motion enables a perfectly level cut to be made.

A contract for the extension of Riverside Drive in New York City between the boundaries of Fort Washington Park has just been awarded. The contract amounts to $625,000.

Comments on Methods of Excavating Trenches and Ditches.

(Continued from June 2 Issue.)

The dressing of the sides of trenches and ditches is an important matter. We will first consider trenches. In shallow trenches, where shoring or sheeting is not needed, the trench needs but little dressing up, it being only necessary to keep the required width and line. In deeper trenches the sides should be kept clean of all loose earth; when the sides are left in a raveling condition, dirt sifts off the sides, interfering with the free work of the men laying pipe in the trench, and, by collecting in the bottom of the trench, causing extra work, after the excavating gang has left the trench. The easiest method of keeping the sides clear of loose earth is by going over them with a shovel or spade. A pick is too slow and expensive for this class of work, while a mattock in the hands of a workman will mean that the work will be done better than it need be.

In excavating deep trench, where shoring is not necessary, care must be exercised to prevent the trench from being a greater width at the bottom than at the top, or else the banks will become top-heavy and cave in. This frequently happens. If the trench is made narrower at the bottom than at the top, the banks will stand up, but there may not be room enough to lay the pipe or conduits. The sides of a trench should always be vertical. This is very necessary when shoring or sheeting is used.

When sheeting is placed the sides must be dressed up much better than when none is used. In certain classes of material this dressing can be done with a shovel, but in stiff clays, especially with a wide trench, the long cutter mattock is a better tool for dressing the sides. This refers to timber sheeting. In driving boards when using vertical sheeting they are readily broken if the sides are left rough, with the result that the boards can be used only a few times. When horizontal sheeting is used the sides must be well dressed to admit of the boards being placed evenly and close to one another. When steel sheet piles are used the sides need not be dressed as the piles are, or should be, driven ahead of the excavation with the exception of the top foot or two. This is one of the advantages of using steel sheet piles over those made of timber.

The dressing up of the sides of ditches is viewed from an entirely different standpoint. As ditches are to remain open there are only a few cases where the sides should not only be well dressed but also sloped. The writer has noticed that many ditches that should be sloped and dressed are not given this finish, while others that do not need it are both sloped and dressed.

This is particularly so of ditches cut for stream diversions in connection with the building of railroads, especially in undeveloped sections of the country. Many engineers lay out a ditch of relatively the same size as the old channel of the stream, sloping and dressing up the sides of the ditch and giving it a fair gradient. This is a mistake and a waste of money. If a stream has a channel varying from 6 to 8 ft. wide a ditch can be dug about 3 ft. wide, say wide enough to admit of excavating it with a drag scraper, and its sides left vertical. The grade given to it need be very slight. Then if the old channel is well drained the water will be diverted into the new ditch, and the first heavy rain will excavate the ditch to its proper size and grade and the action of the water and frost will slope its banks. The writer recalls diverting a stream in Arizona that had a bed varying from 25 to 30 ft. in width. He laid off a ditch just wide enough to take a Fresno scraper—namely, from 4 to 5 ft. wide. The excavation was done with these scrapers at a low cost, the banks being left vertical. The grade was such that the water dammed up quite a little before it ran through the new ditch, but the first rains washed out a channel about as wide and deep as the old one. However, this plan can not always be followed when the country is well settled and the land is valuable, for then it may be necessary to keep the stream under control.

Ditches dug for irrigation, drainage and for power purposes, should be made their full size and the banks should be sloped and dressed. A 1 to 1 slope is very commonly used, although this is varied from ½ to 1 to 2 to 1. Such slopes should be dressed up and trimmed, as the ditches can be kept clean easier. For irrigation and other purposes it is frequently necessary to line ditches.

The lining of ditches and canals to prevent the loss of water by seepage, of course, is not necessary where water is plentiful, but when water is difficult to obtain and for irrigation work it is, the loss of water then becomes so important that a suitable lining must be provided. Measurements of loss by seepage made on a large number of irrigation ditches in California, show an average loss on main canals of about 1 per cent for each mile that water is carried. On laterals in some cases the loss amounted to 11 and 12 per cent per mile. At times, however, the loss has exceeded 50 per cent.

In gravelly soil the loss is always excessive, and the water so lost from irrigation ditches and canals is more than wasted, as this water collects on lower lands, filling the soil and rotting or drowning the roots of trees and plants, and when it collects in pools becoming a place for the breeding of mosquitoes. (For data on the seepage of water from ditches see ENGINEERING-CONTRACTING, Dec. 2, 1908, p. [illegible].)

To prevent this seepage ditches should be lined. This lining is done with puddled clay, oil, either sprayed on the surface of the ground or tamped into the soil, with grouted or cemented rubble paving with cement mortar, cement and concrete, and concrete made either with cement or lime or a mixture of the two. For information on methods and costs of lining and results obtained, see ENGINEERING-CONTRACTING, Dec. 2, 1908, pp. [illegible] and Dec. 30, 1908, pp. 151-6.

The lining of ditches, besides preventing loss by seepage, accomplishes three other purposes. First, the ditch can be kept clean easier. The smooth lining does not impede the suspended matter as readily as does an unlined ditch, nor do weeds and grass grow in the lining to become a deposit, at the end of each season, of decayed vegetable matter. The actual work of cleaning out of the ditch is also made easier. Naturally if a ditch is allowed to fill up, the volume of water is greatly reduced, and this may mean much when the ditch is used for either irrigation or drainage purposes or for power.

If a ditch is not lined, the edge of the ditch, even if it is made a straight line when constructed, soon becomes uneven and grown up with weeds and brush. This not only mars the appearance of the ditch and consumes some water, but impedes the flow of the water and reduces its carrying capacity slightly. Little stagnant pools also form as a breeding place for mosquitoes.

The third effect of a lined ditch is to prevent the water from washing the ditch deeper and scouring its sides or banks. Not only does the water in the ditch do this, but rain water falling on or near the banks wash them badly. However, a cheaper lining will often prevent this as well as the more expensive kinds listed above. A dry stone paving or even crushed stone spread over the bottom and sides of the ditch will serve for this purpose.

Trenches and ditches are excavated for many purposes. Among them are the following:

Core Wall Trenches.—These are excavated in connection with reservoir embankments, to give a foundation to the puddle, masonry or concrete core wall built to prevent the percolation of water under the embankment either at the original surface of the ground or through the subsoil. The width of these trenches depends upon the width of the wall, but the trench is generally made several feet wider than the masonry wall so as to allow of some selected material to be placed on each side of the wall and be well compacted. The cost of placing this material is as a rule paid for in the price of excavating the trench. The material excavated from the trench is placed in the foundation of the down side of the embankment. Core wall trenches are carried down to either bed rock or to some hard, impervious material or else the core walls will not accomplish their purpose. When puddle is used for a core wall then the backfilling of the trench is done by the placing of the puddle. The method of digging these trenches varies with their width and depth and also with the size of the reservoir to be built.

Muck Trenches.—Are shallow trenches of like widths excavated under impervious embankments, dikes and levees. Their use is somewhat similar to core-wall trenches—namely, to prevent water from percolating under the earthen embankment. Their name is derived from the puddled earth made of selected materials with which they are filled. Under most specifications the placing of the puddle is paid for with the excavation, while other contracts pay for both items of work under separate items. These trenches are generally wide enough to admit of excavating them with scrapers, but at times they are dug by hand or with other excavating machines. Frequently the ground in which they are excavated has grown up with trees and other growth, so that there is much clearing and grubbing to be done. This prevents the use of machinery of some kinds.

Foundation Trenches.—Nearly every structure built has some excavation or puddling for its foundations. For buildings there is generally cellar excavation and some foundation trenches are dug. For other structures, such as masonry dams, weirs and bulkheads, the trench is dug to reach the bottom or hard ground. It is often necessary to sheet these trenches, especially if carried to any depth. The smaller trench foundations are generally dug by hand—pick and shovel—but the larger trenches may be generally dug by hand or with scrapers and wheelers. Long trenches of small width may be done with other machines. This class of work is either paid for by the cubic yard or by a lump sum based on plans furnished. Sometimes the cost of excavation is included in the price paid for the structure.

Sewer Trenches.—Trenching for sewers vary exceedingly as does the variety of trenching to make them. Such trenches vary from 1 to 30 ft. in width. The depth of the sewer trench is governed by the grade and the topography of the land. Often a sewer carried to a small valley and then carried through a hill may be from 3 to 50 ft. below the surface. The main sewer trenches are very deep, but [illegible] instead of carrying it down to extreme depths, much of this kind of excavation is done by driving tunnels, but the writer has seen trenches over 50 ft. deep. Various machines are used in excavating such trenches. After reviewing many of the methods of excavation in detail we will give some costs and tabulated data on these machines. Occasionally trench excavation is paid for separately and paid for per cubic yard and the backfilling is not included in [illegible] but under good contracts the excavation and backfilling is included in a lineal foot price of the completed sewer. However, when the sewer is other than pipe and especially when several materials, such as brick, stone and concrete, are used, engineers are learning that better prices are obtained by letting all work, including excavation, on the same basis of a cubic yard.

Conduit Trenches.—These trenches are similar to those employed for sewers except that they are always shallow, as it is not necessary to carry them on a continuous grade, the grade line being established between two manholes. These trenches are either paid for by the cubic yard of excavation, including the backfilling, or are included in a price per lineal foot of conduit placed work.

Pipe Trenches.—Such trenches are used to carry water, gas, steam or refrigerating pipes. Trenches of this character vary in width, but are never very deep unless they are carried under or structions. In some cities galleries to carry such pipes and also conduits are being built. This saves the cost of excavating a large number of individual ditches and admits of easy access to the pipes to make alterations, new connections and repairs, thus saving the tearing up of our streets. The trenches excavated for pipes are paid for in a manner similar to sewer and conduit trenches, and the methods of excavating them are similar.

Manholes.—In pipe sewer and conduit trenches pits are dug at frequent intervals for manholes, traps or valves chambers. Even if machinery is used to excavate the trenches, the extra width needed for the manholes is dug by hand. The method of paying for this excavation is generally included in a lump sum price for a complete manhole. The work in connection with manholes should be done simultaneously with the other work, but owing to the fact that the materials are frequently ordered late, these holes are left in the trench for some time, gathering debris from the streets and collecting rain water, and adding much to the cost of the work, and often making necessary a special foundation.

Street Railway Trenches.—All street railways are laid in a wide, shallow trench. The material excavated is hauled away, but little of it being used again in the trench. The cost of hauling this earth away and wasting it should always be included in the price bid for the work, but the writer has known it to be omitted upon several occasions. If the road is to be either an underground electric or a cable road, a narrow trench has to be excavated below the trench meant for the track, to carry the cable or the conductor rails, and holes running across this trench must be dug for the yokes, manholes, hatchways and boxes. All of this excavation is paid for in the price per lineal foot of completed track.

Drainage Trenches.—These are used to carry drain pipes and tiles, either to carry water from some structure or to drain some area of wet or marshy land. They are seldom more than 4 or 5 ft. wide, and although excavated to a grade that will carry off the water, yet they are seldom deep. Many of these trenches are dug by hand, but there are a number of machines that will do the excavation, and some of them also lay the tile or pipe. These trenches are always backfilled and the prices paid include this work and likewise the laying of the tile or pipe. It must be remembered that the distinction between these trenches and drainage ditches is that the ditches are not filled in.

Drainage Ditches.—Are meant to carry water in the open ditch, for drainage purposes. When such ditches become wide and deep, they are no longer known as ditches, but are termed canals, although both in drainage and irrigation systems, all lateral canals are, as a rule, called ditches. Thus a ditch in one system may be of larger size than a canal in some other system. It is exceedingly difficult to draw a fine distinction between a ditch and a canal, just as it is between a creek and a river, as some creeks are larger than some rivers. Drainage ditches are dug by hand, but, as miles of such ditches are being built in this country each year, there have been a large number of machines built to do this work, also for canal work. Some of these machines slope the banks of the ditches, which is always necessary, as frequently explained. We will describe these machines later. Ditch work is paid for by the cubic yard excavated.

Irrigation Ditches.—Our remarks on drainage ditches are applicable to irrigation ditches. However, in irrigation work there are small ditches used between rows of trees and plants that tap the lateral ditches and carry water to the roots of the plants. Such ditches are made by the former, either by hand or with a light turning plow, or some sort of a scraper.

Roadbed Ditches.—Ditches are excavated for drainage purposes in connection with both wagon roads and railroads. Small ditches are always made in cuts. For railroads these ditches are made 12 ins. deep, 12 ins. wide on the bottom and with 1 to 1 slope on the sides, making a ditch 3 ft. wide on top. This is for cuts through earth. Same engineers use the same size and kind for wagon roads, but as such a ditch has to be excavated by hand, the shape is changed on wagon roads so as they can be excavated by plows, scrapers, road machines or elevating graders. This is done by carrying the slope of the roadbed to meet a shoulder of the side of the cut, thus forming a V-shaped ditch.

Surface Ditches.—Such ditches are excavated to prevent rain water from running into railroad or wagon-road cuts, or against embankments. These are generally small ditches, with the sides sloped, and are excavated by hand, the material from the ditch being thrown on the side of the ditch, between the ditch and the object it is to protect. Like roadbed ditches, these are paid for by the cubic yard of material excavated. These surface ditches are often termed berme ditches, but the writer believes they should be called surface ditches in order to distinguish them from the ditches described in the next paragraph.

Berme Ditches.—In building railroad and wagon-road embankments, the material is often obtained from ditches on each side of the embankment, leaving a berme from 4 to 10 ft. wide between the toe of the embankment and the ditch. This berme gives the ditch its name. These ditches are excavated by hand, by scrapers and with elevating graders. They are paid for, in many cases, by the cubic yard of material as shown by cross sections of the embankment with an allowance for shrinkage. The proper way should be by cross sections of the ditches themselves.

Power Ditches.—These are ditches for carrying water from a dam or stream to a power generating plant or mill, and for taking the water away from the plant if it is not emptied directly into the stream. When used in connection with mills they are termed mill races, and the ditch carrying away the water is called a tail race. For electrical power generating plant the power ditch carries the water to the penstock or a penstock pit, and at times the penstock runs directly to the canal or dam, doing away with the ditch. The excavation is done either by hand or with machinery and is paid for by the cubic yard. Such ditches are lined when it is necessary to prevent wasting water.

Military Trenches.—These are really ditches, as they are not excavated with the intention of filling them in. They are excavated, and the earth thrown up on the side of the ditch towards the enemy to protect the soldier from being shot. The earth thrown up is known as a breastwork. For temporary purposes the ditch is made wide and deep enough to obtain enough earth, so that when it is piled up it will stop a bullet, the soldier lying down or kneeling behind the breastwork in the trench. Such ditches are made long enough to protect a company or regiment. When an army expects to be intrenched in one position some time, as in a siege, the ditches are made much wider and deeper, so that men in single or double file can march through them, while others are in position behind the breastwork. Then the breastwork and ditch together must give a height of 6 to 8 ft. and a step is cut in one side of the ditch for men to stand on as they are shooting over the breastwork or through pockets made for that purpose. The men also live in these ditches, so holes are dug in the sides to build fires for cooking. Such ditches may extend for miles when a large army is entrenched. When such ditches are extended out into square or rectangular shape and cannons placed behind the embankments thrown up, they are termed forts. All such work is done with picks and shovels, though soldiers have dug small temporary ditches and breastworks with their bayonets.

Rifle Pits.—Are small ditches, long enough to protect one or two men, and are excavated in the same manner as other military ditches.

In excavating ditches and trenches, especially the latter, an important consideration is the placing of the excavated material on the side of the trench. The earth should be kept well away from the sides of the trench. The greatest mistake is made as the work is started. The workman is allowed to throw the top soil within a few feet of the side of the trench, thus as the trench is deepened it becomes necessary to throw the dirt to a greater height, and also a greater distance horizontally, which means a greatly decreased amount of earth handled per man per day. It is very difficult for a foreman to prevent men from handling earth in this manner, but his time will be well spent if he succeeds in changing their method of placing the earth on the side of the trench at the start.

To illustrate by an example. A trench 5 ft. deep and 3 ft. wide has excavated from it 15 cu. ft. per lin. ft. of trench. In average earth this material will swell, upon being loosened and shoveled, 20 per cent; thus this material will make a pile on the side of the trench with a triangular section 9 ft. wide on the base and an altitude of 4 ft. If this pile is started within a few feet of the trench, it will be made higher than 4 ft., and as the pile becomes high and the trench deeper, earth from it will sift back into the trench so that another workman will have to keep the edge of the trench clear by throwing dirt over the top of the pile. If this is not found absolutely necessary, then the man in the trench will have to throw his dirt much higher than 4 ft. and also must send it over the top of the pile to prevent it from falling back into the trench. A man does less work in raising earth vertically than horizontally. On the other hand if the first material excavated from such a trench is thrown about 9 ft. from the side of the trench, then the pile of earth from this size trench should never be higher than 4 ft., and it will not be necessary to handle any of the material twice. Another important item in placing the material on the side of the trench is to teach the workmen to throw their dirt, after they have made a small pile, so that it lands just over the top of the pile on the back slope; then it runs away from the trench instead of towards it. This also leaves a small space on the bank between the pile of dirt and the side of the trench.

Two advantages are obtained by this method. A small space is left free of earth to allow men to work over the trench, and the weight of the pile of earth is not so apt to cave in the sides. The writer has [illegible] a [illegible] of [illegible] trench [illegible] by the method [illegible] would [illegible] it the earth [illegible] to the trench. The [illegible] the distance out from the trench [illegible] placing the earth is as follows:

Rule: For trench [illegible] deep divide the total cubic [illegible] including the allowance for swelling, by [illegible] and the resultant is the distance in feet from the trench to start throwing the earth. For a trench between [illegible] and 10 ft. deep divide by 3.

Trenches of a greater depth than 10 ft. have to be handled in two lifts, hence the rule is not used for deep trenches. The rule gives piles of dirt 4 ft. high for shallow trenches and 6 ft. high for deeper ones. Dirt can be thrown the necessary distance from the trench if long handled shovels are used, and as previously stated, such shovels should always be used in trenches and ditches.

When pipe or other work is to be done in the trench the excavated material should always be placed on one side of the trench only, unless the trench is very wide, as then one side is reserved for serving materials to those working in the trench. However, if all the material is not back filled, then that part which is to be hauled away can be put on the opposite side from the stock pile, provided it is hauled away promptly enough not to interfere with other work. If the trench is a wide one, these same principles can be carried out. The dirt should always be kept away from the trench, for every time even a few grains of sand fall into the trench the men stop work to look up to see what is the matter, and swear at the man who may have caused the sand to fall.

The production of pig iron for the year 1908 has been compiled by the U. S. Geological Survey for "Mineral Resources of the United States, 1908." The output is given as 15,936,018 long tons, a decrease of 38.19% from the output in 1907. The value of this pig iron, on board cars at the furnace, is given as $254,321,000, which is 52.01% less than the value of the 1907 output. The product derived from imported foreign ores has been considered such a small percentage of the total that it could be neglected in this compilation.

Consul Abraham E. Smith, at Victoria, reports that final agreement has been made between the provincial government of British Columbia and the Grand Trunk Pacific Ry. Co. in regard to the water frontage at Prince Rupert. The total frontage of the town site upon the harbor at Prince Rupert is 28,000 ft., or about 5.3 miles. This is divided in ten parts, of which the Government retains five, alternating, and having an aggregate frontage of 8,500 ft., the remaining five, with a total frontage of 19,500 ft., going to the railway company. The harbor is formed by a protected curved inlet 16 miles long, a mile broad, and 26 fathoms deep on an average. The bottom has good holding for anchors, and there is 30 feet of water at the lowest tide.

During the year 1908 the steam and electric railroads of the United States purchased more than 112,000,000 crossties, costing at the point of purchase over $56,000,000, an average of 50 cents each, according to statistics just made public by the Bureau of the Census in cooperation with the United States Forest Service. This was some 40,000,000 ties less than the quantity purchased in 1907, when the total was approximately 153,700,000, the highest ever recorded.

Roads and Streets Section

Note: This Section is devoted to methods and costs of road and street construction. It will cover road building in all its details, the construction of pavements, sidewalks and gutters, the testing and use of paving materials and the machinery and tools used in road building and paving.

The Theory of Economic Road and Street Design and Location.

IX

Pavement Defined.—A pavement is a shelterlike covering built upon the soil to form a firm unyielding roadway for wheeled vehicles and animals.

This definition includes any artificial highway covering built upon an earth subgrade, from the cheapest gravel road to the most expensive granite block pavement. English engineers have been in the habit of not calling macadam a pavement, but, as macadam performs every function that any pavement performs, there is no logical reason for excluding it from the list of pavements.

Functions of a Pavement.—Every pavement has three functions to perform:

(1) Distributing concentrated wheel loads over the earth subgrade.

(2) Roofing the earth subgrade so as to prevent its saturation with water.

(3) Giving a hard, clean, smooth (but not slippery) surface that reduces rolling friction.

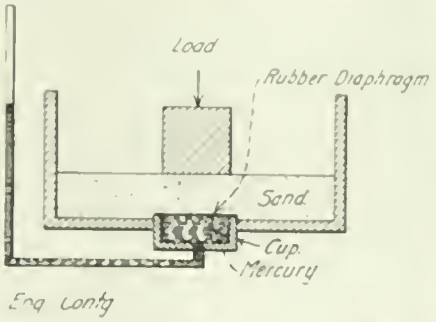


Fig. 1—Gage for Measuring Pressure Transmitted Through Sand.

A sheet of tin is hard, clean and smooth, yet it would make a poor pavement not only because it is slippery but especially because it would not perform the first and most important function of distributing the wheel loads over the subgrade.

In its action of distributing concentrated wheel loads a pavement is like a snowshoe. By furnishing a large enough bearing area upon the snow, a Norwegian snowshoe distributes the weight of a man so that the pressure upon the snow is about 0.2 lb. per sq. in. This pressure is sufficient to compact the snow slightly beneath the shoe, and the compacted snow in turn distributes the load over the loose snow beneath. A pavement is, in reality, an earth shoe and acts almost precisely like a snowshoe.

The economic importance of a clear conception of the main function of a pavement can not be overestimated. Most of the uneconomic designs of pavements and roads [illegible] be traced to a lack of sufficient recognition of the load distributing function of a pavement.

Measuring the Distribution of Pressure on the Subgrade.—The writer has long realized [illegible] of the reasons why road and street pavement design has remained empirical has been the [illegible] the bearing power of soils and the load [illegible] distributing effect of pavements of different kinds and thicknesses. Some years ago Mr. Richard L. [illegible] had [illegible] of the [illegible] experiments on the load distributing effect of ordinary sand. The experiments [illegible] similar experiments should be conducted. Figure 1 shows the device used for measuring the pressure at the bottom of a layer of sand produced by a concentrated load placed directly above the pressure gage. The pressure gage was a small iron cup filled [illegible] with mercury and covered with a diaphragm of thin rubber. From the bottom of the cup passed a small glass tube. [illegible] brought up [illegible] by [illegible] the rubber diaphragm slightly upward. A layer of sand 1 in. thick was placed over the diaphragm and a concentrated load was applied directly above the cup, the load resting on a circular block 1 in. in diameter. The height of the mercury column then indicated the pressure.

Changes were made both in the thickness of the layer of sand and in the weight of concentrated load. Much to the astonishment of the experimenters, it was found that the pressure indicated by the gage varied inversely as the cube of the thickness of the sand layer. Thus a 2-in. sand layer reduced the pressure to one-eighth of that registered through a 1-in. sand layer.

Authors of various text books on roads and pavements have often used an illustration like that in Fig. 2 to illustrate what they have conceived to be the method of distribution of a concentrated wheel load over the earth beneath a pavement. They have believed that a conical pressure is produced, and that consequently the pressure on the base of the cone varies inversely as the square of its altitude. The experiments above referred to upset this theory completely so far as distribution of pressure through a granular mass is concerned, and it is altogether likely that similar experiments with rigid paving layers will likewise upset the "cone of pressure" theory as applied to any pavement.

With the device shown in Fig. 1 it is such a simple matter to investigate the load distributing effect of pavements that it seems [illegible] when highway engineers [illegible] to determine the bearing power [illegible] and then design pavements [illegible] thickness [illegible]. Investigations of the load distributing power of granular courses and of pavements would make excellent subjects for the graduating theses of engineering students.

[illegible]

of results. First, there is no way of knowing where the rolling has produced sufficient consolidation of the earth subgrade. Second, there is no way of knowing whether there are any "soft spots" that have been bridged over by the roller. In brief, you can not inspect a subgrade that has been rolled with an ordinary roller, and unerringly determine whether it is uniformly and sufficiently dense. But this is not all. Natural soil often varies materially in its density at points only a few inches apart. Hence, no matter how carefully the rolling may be done, the consolidation under the broad tire of a roller is not uniform. It was this fact that led to the invention of grooved rollers, which was a step in the right direction, but which fell considerably short of giving satisfaction. Even with a grooved roller, there is a great deal of "bridging" over soft spots.

Finally, both smooth rollers and grooved rollers produce a consolidation of the earth that is quite satisfactory only in a very thin layer at the surface, and is less and less satisfactory every increased fraction of an inch below the surface. Figure 3 illustrates the effect of rolling by pressure applied at the surface of the subgrade. Now that we know that the pressure beneath a roller varies inversely as the *cube* of the depth of earth below the face of the roller, we can understand why it is that proper consolidation of an earth subgrade extends such an insignificant distance down.

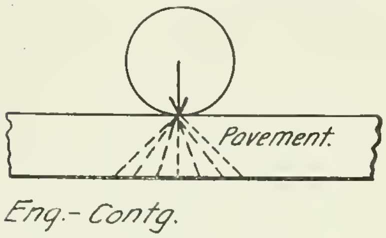


Fig. 2.

A few years ago, Mr. John Fitzgerald invented not only a new type of roller, but a new way of consolidating earth subgrades. His roller, which has been extensively used in California for building oiled roads and is manufactured by the Petrolithic Pavement Co. of Los Angeles, is provided with numerous projecting tampers that sink up to the "hilt" in plowed ground. In compacting a subgrade with this rolling tamper, the first step is to break up the earth completely with a plow. The next step is to harrow it with a spiked tooth harrow, thus pulverizing all clods and also mixing the soil. The comminuted earth is then sprinkled lightly with water, and the rolling tamper begins its work. A 5,000-lb. rolling tamper is drawn by four horses back and forth over the subgrade. The tampers sink out of sight in the earth and begin their tamping action at a depth of 6 or 8 ins. below the earth surface. Gradually, as the earth becomes consolidated at the bottom, the tampers begin to ride higher and higher, until finally they ride upon the top of the thoroughly compacted subgrade. This riding of the tampers on the hard surface is the *test* of sufficient consolidation. The rolling tamper, therefore, gives its own test of effectiveness, and at the same time produces a thick layer of densely compacted earth, uniform in density both laterally and vertically. Figure 4 illustrates the uniform effect vertically, as contrasted with ordinary rolling effects shown in Fig. 3.

A loamy earth weighing 90 lbs. per cu. ft. in place can thus be uniformly compacted until it weighs 120 lbs. or more. To ascertain the weight of "earth in place," dig a hole in it before it has been plowed, measure the hole carefully and weigh the earth excavated from it. In like manner ascertain the weight of the earth after tamping.

Mixing Soils Before Tamping.—Sand that contains no loam can not be consolidated satisfactorily by rollers or tampers of any kind. When such sand is encountered it will usually pay to haul in loam or clay sufficient to fill the voids in the sand to a depth of 4 to 6 ins. To fill the voids in a 6-in. layer of sand will require a layer of loam or clay 2 to 2½ ins. thick. If the clay is lumpy it will have to be wet until it becomes a puddle, and then harrowed or otherwise mixed with the sand. An effective method of mixing is to use a road machine. The blade of the machine is set at an angle that will throw the 6 or 8-in. layer of sand and clay off to one side of the road, in a sort of windrow. Then, on the return trip of the machine, this windrow is thrown back into the road. A few trips back and forth are very effective in mixing the materials. After the mixing has been completed, the mass is tamped as above described.

Gravel that contains insufficient loam for a binder should be treated in the manner just described for sand.

Mixing Soils with Tar or Oil.—There are many soils whose bearing power can be most cheaply increased by mixture with a bituminous binder, 2 to 3 gals. per sq. yd., and compacting with a rolling tamper. Indeed, many soils treated in this manner need no further treatment to produce a pavement that is satisfactory. But we are speaking now more particularly of the preparation of a suitable subgrade. Asphaltic oils and tars are evidently destined to play a very important part in enabling engineers to solidify natural soils to such a degree that they will effect a remarkable distribution of concentrated wheel loads over the soft subsoil beneath. Such bitumens have the added advantage of filling the voids of the soil with a waterproof material.

The Economy of Subgrade Consolidation.—If a given soil in its natural condition will safely sustain a pressure of 15 lbs. per sq. in., it may require a pavement 6 ins. thick to distribute a wheel load of 2,000 lbs. over a sufficient area to produce no pressure greater than the limiting 15 lbs. per sq. in. But, by consolidating this subsoil, as above indicated, the compacted portion really becomes a sort of pavement itself. Indeed, it does then perform the first function of a pavement—the distribution of wheelloads over the subsoil. It is clearly cheaper to accomplish the main object of wheelload distribution by scientific consolidation of the subgrade than by giving added thickness to the pavement.

With team and driver at 50 cts. per hour, a subgrade can be plowed, harrowed, sprinkled and tamped for less than 4 cts. per sq. yd., and this provides a liberal allowance for hard plowing and clod-breaking; the tamping alone costs only 1½ cts. per sq. yd. as a maximum, so that there are many soils where plowing, sprinkling and tamping cost less than 2 cts. per sq. yd.

When one remembers that a square yard of macadam 6 ins. thick rarely costs less than 60 cts., the great economy of properly consolidating the subgrade for macadam is apparent, for a 2-in. reduction of thickness of macadam causes a saving of 20 cts. per sq. yd.

A 6-in. base of concrete seldom costs less than 70 cts. per sq. yd., so that a saving of only 2 ins. in its thickness means a reduction of 23 cts. per sq. yd.

The writer is satisfied that, so far as thickness needed for wheel load distribution is concerned, 3 ins. of macadam or concrete on a properly prepared and tamped earth subgrade is sufficient in most cases.

Designing an Economic Base.—A pavement is often composed of two layers—(1) a base, and (2) a wearing coat. The function of the base is solely to distribute wheel loads, for the wearing coat should perform the other two functions of the pavement—rain-shedding and reduction of rolling friction.

We have seen how the proper treatment of the subgrade will relieve the pavement base of much of its duty, and, therefore, reduce the necessary thickness of the base.

In designing a pavement it is always well to have distinctly in mind this one function of the base—the distribution of wheel loads—for, by so doing, the designer will avoid the use of expensive materials for the base. Thus, in macadam road design, it is frequently most economic to use local rock, even shale, for the base, and an imported trap for the wearing coat. Yet it is not uncommon to find statements in textbooks on roads to the effect that all shales and most sandstones are utterly unfit for macadam road construction. It is often true that they are unfit for a wearing coat, but evidently the authors of such books have not thought of macadam as a pavement divisible into base and wearing coat.

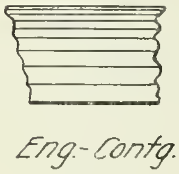


Fig. 3.

Fig. 4.

In New York State, a 2-in. wearing coat of trap rock is often placed upon a 4-in. base of local stone, in building macadam roads. Nor need an engineer fear that the 2-in. wearing coat will "scale off," even though it be laid on an old, hard, unscarified macadam of local stone.

In designing a base, aim to use the cheapest material available, regardless of its resistance to abrasion. In some cases this is a gravel, in others it is shale, in still others it is a good quality of broken stone. In none should it be a material selected because of its wearing qualities, or its dustless qualities, for it is the function of the wearing coat to supply those qualities.

(To be continued.)

The Pennsylvania state highway, extending east to west across the state, is not to be built. The bill providing for its construction which was passed by the legislature was vetoed by Gov. Stuart. Work on highway improvement will be carried on by an appropriation of $2,000,000 to be available during the next two years, which is about the same amount that the state has expended on the work during the past six years. A bill was also passed extending the aid of the state in a certain amount of road improvement work carried on by townships.

The Prussian Government is to issue a loan, the proceeds of which are to be used for the construction and equipment of new branch line railroads. The total amount to be expended under this loan bill is $55,753,000.

Some Experiments on the Resistance of Pavements.*

[illegible]

The city of Toronto in the year 1908 was a party to an application before the Dominion Board of Railway Commissioners for the abolition of grade crossings along its waterfront. The railway companies interested held that the streets should be elevated and carried over the tracks by bridges. It was claimed by the city, on the other hand, that grade separation could be accomplished best by elevating the tracks and leaving the streets at the present level, the argument being that the grades on bridge approaches for vehicular traffic, suggested by the railway companies, would exceed the grades which would be otherwise obtained. The city therefore took a strong attitude in favor of maintaining the street crossings at the present level and elevating the tracks.

The prediction of [illegible] the [illegible] of heavy grades in increasing the expense of haulage from the water front to the central portion of the city was, [illegible] therefore, a [illegible] part of the [illegible] [illegible] and [illegible] in this connection, and the writer carried out the experiments herein set forth.

No attempt was made to determine the [illegible] of the [illegible] that could be [illegible] on the [illegible] in a short distance. The experiments were intended to cover only the simple problem of determining the resistance of pavements to tractive effort.

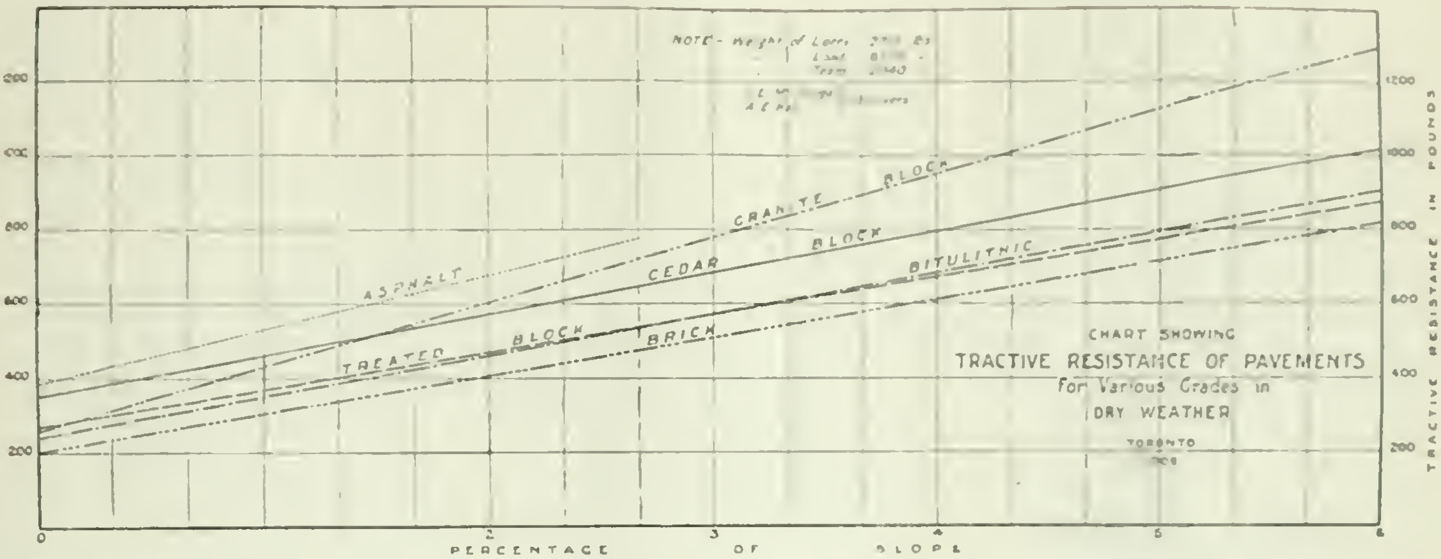
The pavements included in the experiments are as follows: asphalt, bitulithic, brick, cedar block, granite block, and treated wood block. It seemed advisable to separate the results obtained under the conditions of wet and dry weather.

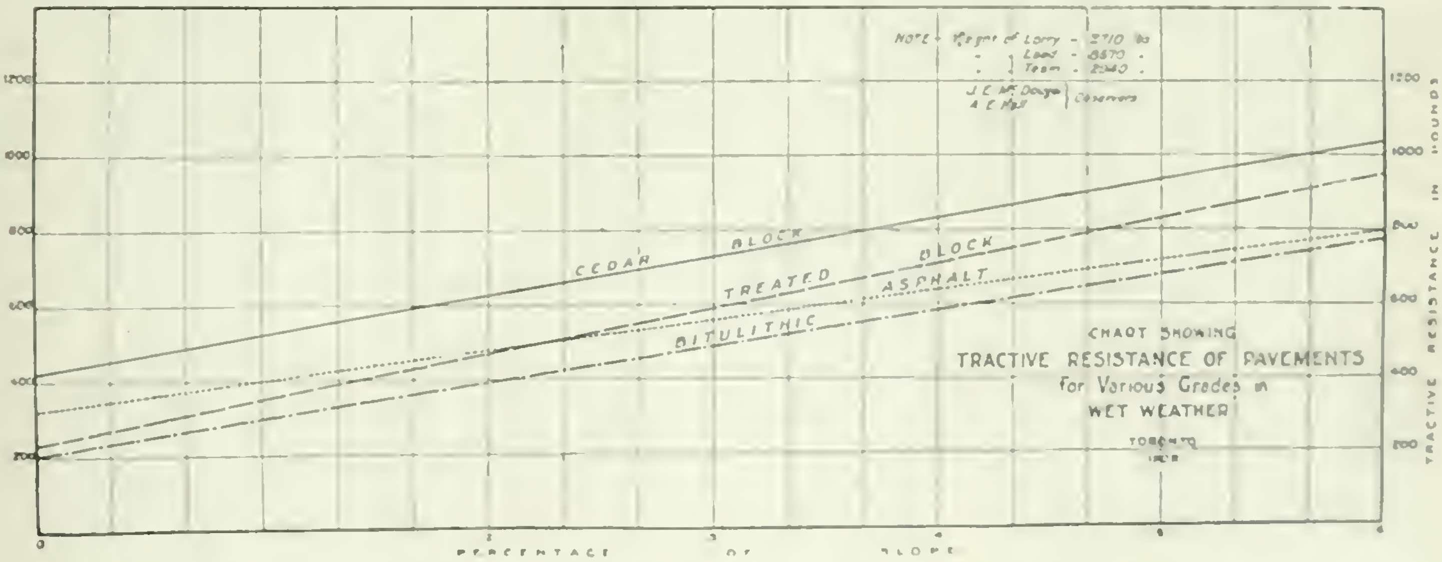
All the experiments were made in the month of May, 1909, under various conditions of summer weather, and several different classes of pavements were [illegible] [illegible] with the view of making [illegible] [illegible] [illegible]

[illegible]

Some slight difference was to be noticed between the results obtained under conditions of wet and dry weather among all the pavements examined, but the only striking difference occurred in the case of asphalt. In dry weather, owing to the intense [illegible] and the heat of the day, the results for asphalt varied considerably from hour to hour. Under the [illegible] [illegible] the sun the pavement became much softer and formed a wavy surface in advance of the wheels of the vehicle, and the effect was that of causing the vehicle to advance along a continuous up grade, due to the depression of the pavement caused by the wheel load. With other pavements this effect would be negligible, and the slight difference between the readings for wet and dry pavements [illegible]

[illegible]





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*From a paper read before the Canadian Society of Civil Engineers, April [illegible], 1910.

particular curve must be regarded more as an illustration than as a definite result. No observations were made for brick pavement during wet weather.

All the experiments were made with a good steady team of horses, weighing 2,940 lbs., drawing a lorry weighing 2,710 lbs. The weight of the load was 8,570 lbs. A standard Fairbanks dynamometer was used to indicate the pull exerted by the horses in drawing the loaded vehicle. The method of carrying out the experiments was as follows: The first observer paced off the distance alongside the load as it was being drawn along the pavement under the test. The second observer was stationed at the front of the lorry, in such a position that he could watch the readings shown by the dial of the dynamometer. At each ten paces the first observer called out the tally, and the second observer gave the first observer the average reading of the dial during the ten paces. This was noted by the first observer in his note book, while continuing his pacing.

The lorry was of the ordinary type, and the dynamometer was arranged between the double-tree of the lorry and the rear end of the tongue in such a way that all the load was carried through to the dynamometer, the tongue serving merely as a guide for the vehicle.

The work was supervised by the writer under instructions from Mr. C. H. Rust, City Engineer, Toronto, Ont.

Notes on the Tonnage-Life and Wear of Stones in Road Surfaces.

In Liverpool, England, it has been customary to take occasional records of the numbers and classes of vehicles passing along the principal traffic streets, and to reduce these records to a standard of tons of traffic per yard width of carriageway per annum.

At the recent Road Conference held at the institution of civil engineers in London, Mr. John A. Brodie, city engineer, of Liverpool, read a paper calling attention to some remarkable differences in wear of the same stone when used in varying forms of road surface construction as shown by records of traffic tonnage passing over them.

The result of tests made in Liverpool, according to Mr. Brodie's paper, has been to show that there is practically only one type of material economically possible for all classes of stone road surface in that district. The same stone is used in the form of setts, accurately dressed to sizes, along the line of docks, and also in the form of macadam for streets of comparatively little traffic, and some interesting lessons may be learned from its behavior and life under different conditions.

Taking heavy-traffic streets first, Mr. Brodie states that experience shows that accurately dressed setts, 6 in. deep by 6 in. to 8 in. long by 4 in. wide, laid on a sound concrete foundation at least 8 in. deep, with a small sand bed between the underside of the sett and the concrete, the joints being thoroughly racked with hard shingle and afterwards grouted with a permanent pitch mixture, which prevents any movement in the stones, and renders the whole surface perfectly impervious to weather, give a life equal to at least 7,500,000 tons per yard width, and under these conditions this life has often been exceeded. It is at present impossible to say whether an equal tonnage-life can be obtained from the similar but shallower 4-in. class of construction in streets taking, say, 60,000 tons per yard of width, as this would mean a life exceeding 100 years; but experience shows, states Mr. Brodie, that the total average wear of the setts has been exceedingly small, and it is a fact that many such streets exist in Liverpool today having a life of from 25 to 30 years without requiring any important repairs during that time due to wear of the material.

Mr. Brodie further states that when the same quality of stone is used in ordinary macadam laid 6 in. to 7 in. deep on a sound, hand-pitched foundation, experience shows that the tonnage-life of the surface before requiring to be recoated is enormously decreased, and instead of 7,500,000, a figure about 100,000 tons only, or about 75 times less than the result for setts previously given, has been obtained on a street of moderate traffic—a somewhat startling difference. Of course, the two figures may be said to be hardly comparable, but they are so far all practical purposes, and the broad fact remains that the surface of the macadam has—on the average—worn or been impounded down from 1 in. to 1½ in., while the surface of the sett has not been worn more than from ½ in. to ¾ in. on the average.

It would not be safe to assume, states Mr. Brodie, that the traffic tonnage-life here given for macadam is the average life obtainable from this material in a macadam road, but it is a genuine average life of a series of complete coatings of 1½-in. material on a practically level macadam street laid to a depth of about 6 in. on an excellent hand-pitched foundation, carrying a considerable volume of narrow rubber-tired vehicles, motor-cars and general light traffic, in which it has been customary to keep the surface in good order by completely recoating the whole width of the street as soon as the surface becomes generally unfit for comfortable use by bicyclists.

Another interesting result has also been brought more clearly to light by these records of traffic tonnage. A portion of a macadam road surface has been removed to a depth of 4½ in. and replaced by an equal depth of ordinary macadam stone, laid in two layers spread in the ordinary way, and, after dry rolling, the interstices have been completely grouted or poured up with a permanent pitch and sand mixture, so that each stone is embedded in or surrounded by the mixture, the whole being again rolled while still hot with a 10-ton roller until consolidated and rendered thoroughly impervious. The results up to date show that when properly dealt with on these lines the life of the surface can be extended from 100,000 traffic tons to at least 750,000 traffic tons per yard of width, or 7½ times the average life of the ordinary macadam under the same traffic conditions, though still, it will be observed, only one-tenth of the tonnage-life of the sett pavement street first referred to. This improved result, while also remarkable, might almost be expected when it is borne in mind that embedded in such an elastic mixture the irregularly-shaped macadam stones are firmly held up to their work very much after the condition of stone setts, and not being allowed any appreciable movement, they are so prevented from wear by the rubbing and grinding action so harmful in ordinary macadam.

That this is the case is clearly shown by the section of a piece of this surface, the traffic on which has already exceeded 560,000 tons per yard width, the stones in which have been washed clean by a spray of petrol. While the edges of the stones near the surface are somewhat rounded, the edges of all stones below the surface are as sharp as when originally laid, and this could not possibly be the case where there is any considerable amount of movement among the stones due to traffic.

To obtain the best result with small stones, Mr. Brodie decided that it would be necessary to present a surface of each individual stone sufficiently strong in itself to take the weight of individual wheels without crushing, and at the same time held firmly, so that the abrading action common in macadam should, if possible, be avoided. His first step in this direction was the formation of concrete macadam blocks, in which the wearing surface consisted of selected macadam placed by hand on a true surface in a mould—wearing surface downwards—strong Portland concrete material being subsequently filled in and around the stone to a uniform total depth of about 4½ in., and undoubtedly, when properly matured before laying, these blocks give excellent results as regards wear and quietness.

A sample block has been laid for five years in a street having a traffic tonnage of 25,000 tons per yard width per annum, and it will be seen that though it has already exceeded the ordinary tonnage-life of a macadam surface there is no apparent wear on the stones, and it appears likely that a very long life can also be obtained from ordinary macadam stone under these conditions. They make an admirable and washable street surface for use in poor neighborhoods, where cleanliness and impermeability are of first importance.

In another experimental piece Mr. Brodie adopted a cube of a size, roughly, 2¼ in. by 2¼ in. by 2¼ in., and finds that he can get such a material broken sufficiently accurately for paving by hand at a cost not much exceeding ordinary macadam. It will be noticed that as this depth, together with about 1 in. of stone bedding, is only about one-half the depth of the 6-in. sett used on the rock road, the same weight of material will cover a surface about twice as great, while as its cost per ton is about one-third there is an ample margin to provide for the extra cost of labor in paving the smaller pieces.

This surface has been paved on a depth of small broken stone of the same material, and the joints have been racked with small hard shingle, and both the joints and the layer of broken stone on which the surface stones have been embedded have been grouted and rendered impervious with the pitch mixture used in Liverpool.

The whole surface has been laid on a 6-in. concrete foundation, so that there may be no settlement; and as experience has already shown that there is no possibility of side movement even with sharp or triangular stones embedded in the pitch mixture, it would appear that the conditions of the full-sized sett paving have been arrived at as nearly as possible in the cheaper coating.

In a paper read recently before the Society of Engineers, Dr. J. S. Owens, A. M. Inst. C. E., described the origin and application of a new test for determining the end of the mixing process in preparing concrete. The methods which have been tried in the past to achieve this result were described, three such being referred to: (1) Inspection; (2) making briquets, breaking when set, and examining fracture for even strength; and (3) mixing pigment with the concrete, making briquets, breaking when set, and examining fracture for even distribution of pigment. The author criticized these methods, and showed their lack of value for the purpose. He stated that it had been ascertained experimentally that inspection alone could not detect the difference between concrete having one part of cement to two of ballast, and that having one to three. The following definition of properly mixed concrete was then given:

"Concrete in which the various [illegible] are as uniformly distributed as the [illegible] the particles composing them will admit." He went on to say: "The question, therefore, is how to determine when this uniformity of distribution has been attained." The principle on which the author's test is based was thus described: "If we take a few small samples from different parts of the lump of concrete and if we can tell in some simple way whether all the samples

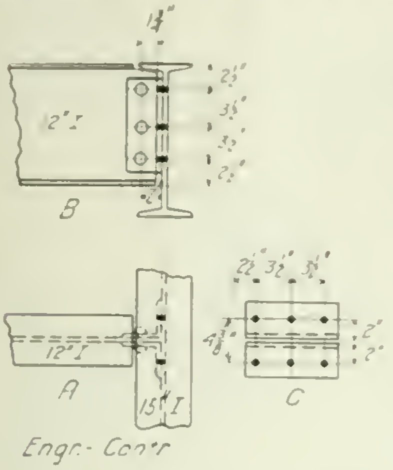

Fig. 1.

contain the same relative proportions of stone, sand and cement, we have a means of telling whether the concrete is properly mixed or not." The author's method of comparing the samples is simply to place each in a tall glass cylinder nearly filled with water, shake them up, and allow them to settle. The rate of settlement of the cement in water was shown to be about thirty times as slow as that of the sand, which, in turn, was slower than that of the larger particles of stone; this caused the stone, sand and cement to settle on the bottom in distinct layers. It was shown that the depth of these layers was proportional to the amount of the material present in the sample, and that in this way it was possible to tell whether each sample had the same amount of cement, sand and stone.

Civil Service examinations to fill approximately 200 vacancies in the temporary positions of junior engineer, surveyor and transitman, in the Engineer Department at Large, War Department, for work in the service in connection with the Intra-Coastal Waterways from Boston, Mass., to Key West, Fla. The salaries of junior engineers will range from $125 to $175 a month. The salaries of surveyors and transitmen will range from $100 to $125 a month. The employment in these positions will be temporary, continuing for from six months to one year. Applicants for the positions of civil engineer must have had good technical training and, in addition, [illegible] three years' [illegible] experience. Applicants for the [illegible] transitman must have had not less than three years' experience in field work as transitman or [illegible] technical training [illegible] for these positions. Applicants [illegible] more than one of these examinations will be required to [illegible] for each one. [illegible] on the date of the examinations.

All records for [illegible] of the Empire District of the Central Division of the Panama Canal were [illegible] on May 12 when 15 steam shovels [illegible] cu. yds. of rock and earth, an average of 1,0[illegible] cu. yds. per shovel [illegible]

Unclassified and General Articles

Note: This section is devoted to methods and cost articles on construction work not properly coming under any of the preceding classifications.

Methods of Designing Skew Connections in Complicated Steel Structures*

By [illegible]

It is but a short period [illegible] ordinary structures and the author has noticed a lack of information along the line of detailing [illegible] skewed connections. It is [illegible] that the mathematician can readily determine the angles required for all such cases, and then draw the details [illegible] While this may be true [illegible] simple [illegible] yet for complicated [illegible] it is [illegible] to present on paper a picture of the whole so that cuts and clearances may be readily determined. It may easily be understood that when a number of [illegible] together at a joint, and these [illegible] or L section, that the [illegible] of fitting them one to another will be [illegible] out in picture language.

The purpose of this paper will be to present, if possible, in [illegible] progressive

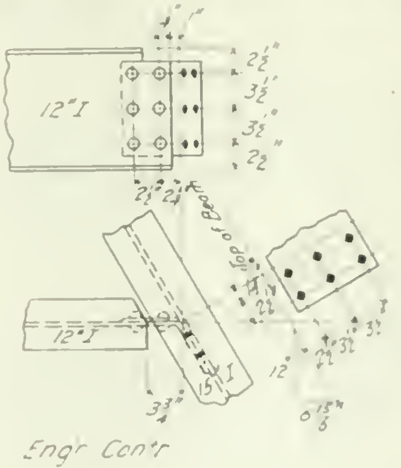

Fig. 2.

manner the way to [illegible] detailing and actual connections which have been used in structures already erected will be taken as illustrations. It will not be the purpose of this paper [illegible] to determine the size of the different members nor to attempt to give the [illegible] of descriptive geometry [illegible] The problems will be presented in as direct and simple a manner as is consistent with the subject.

Figure 1 is an ordinary [illegible] connection [illegible] in plan [illegible] of a 12 and 15-in. I [illegible] the [illegible] with [illegible] connecting [illegible] plate [illegible] the 15-in. I [illegible] connecting angle [illegible] the 15-in. I [illegible] will be noticed that [illegible] is very simple and [illegible] [illegible] [illegible]

Figure 2 shows a simple case [illegible]

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*[illegible] Meeting [illegible] of Civil Engineers, [illegible]

[illegible]

[illegible] direction of flange [illegible] are [illegible] at right angles [illegible] parts in plan.

Figure 3 [illegible] a [illegible] 12-in. I [illegible]

Figure 4 shows a horizontal 15-in. I [illegible] 15-in. I [illegible] slopes [illegible] to the horizontal.

Figure 5 shows a 15-in. I [illegible] Figs. [illegible] slope [illegible] to the horizontal.

Looking back [illegible] general [illegible] of the five figures which have been given [illegible] may now be seen:

(a) In Figs. 1 and 2 both beams are horizontal, the difference between them being the horizontal angle which one beam makes with the other beam. In Fig. 1 the angle is 90°; in Fig. 2 [illegible]

(b) In Figs. 3 and 4 one beam is sloping. In [illegible] Fig. 3 [illegible] while in Fig. 4 [illegible] 15-in. I [illegible] which slopes. In both these cases the beams are at 90° horizontally.

(c) Figure 5 shows both beams sloping, but at 90° horizontally.

These three steps lead up to Figs. 6 and 7 which show not only both beams sloping, but also horizontally [illegible] angles.

Figures 6 and 7 [illegible] a simple 15-in. I hip beam and a 12-in. I with a vertical web framing into it. In Fig. 6 the primary steps alone are shown, [illegible] plan, hip section and normal section. In plotting [illegible] as follows: (a) Lay out the plan [illegible] small scale (usually ¼ in.=1 ft.). (b) Plot the hip section C D [illegible] directly from the line [illegible] The height [illegible] should equal the [illegible] above the horizontal [illegible] scale. Line C [illegible] represents the horizontal base, and line C [illegible] the [illegible] angle [illegible] to horizontal.

(c) The normal section [illegible]

Now that all the angles have been found, the steel may be placed [illegible] it is usual to keep the edges of [illegible]

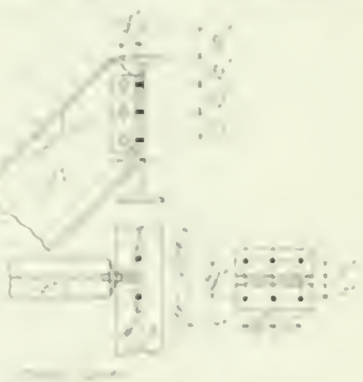


Fig. 3

[illegible] the [illegible] [illegible] The usual details will be plotted to [illegible] scale [illegible] with care [illegible] to [illegible]

(d) A vertical section through the 15-in. I [illegible] flanges of

15-in. I hip about line *BC* in the plan. Project top flange to normal section, keeping edge *E* of flange within roof line D^1B^3. The rise *X* to a flange point on center line of web can be determined in hip section and plotted from edge *E*. Transfer the vertical distance *Y* (which is the height to flange vertically below apex) to hip section. Lay out 15-in. I from this top flange point. Transfer to normal section the vertical height of bottom of flange, *Z*, so that 15-in. I section may be completed.

(e). Plot 12-in. I which frames into the 15-in. I hip beam. Lay out 12-in. I flange in plan, about line *BD*. In normal section lay out 12-in. I having top flange flush with clearance line D^1B^3. Plot connection rivets, adjusting the elevations of same so that cuts on both beam and connection plate will be as neat and few as possible.

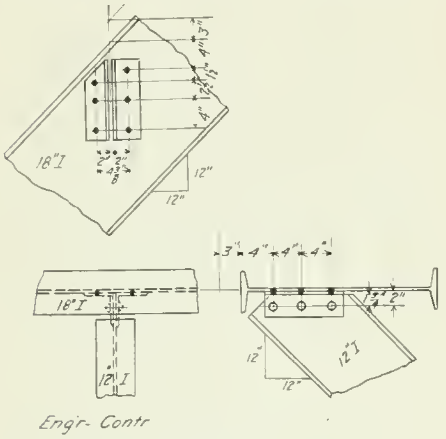


Fig. 4.

A STEEL FRAMED ROOF—BEAM WEBS VERTICAL.

The object of the next four plates will be to present a complete set of drawings which will illustrate the office practice in working out a steel framed roof, when the beam webs are vertical. Although there are no complicated trusses or girders, as is usual in a large roof, nor are the beams of large dimensions, yet this case will do very well in the problem at hand.

Figure 8 is a complete erection drawing of a beam roof having a general slope of 7 ins. to 12 ins. The ridge is not horizontal throughout but steps down where the walls narrow. This step, and the hip end, have a somewhat steeper pitch than the rest. The plan locates all the beams in a horizontal direction, showing exactly the intersection of every beam, whether hip, valley, ridge, or eave. The elevation, and sections locate all the vertical distances; such as the height of ridge beam below apex, the column heights, etc.

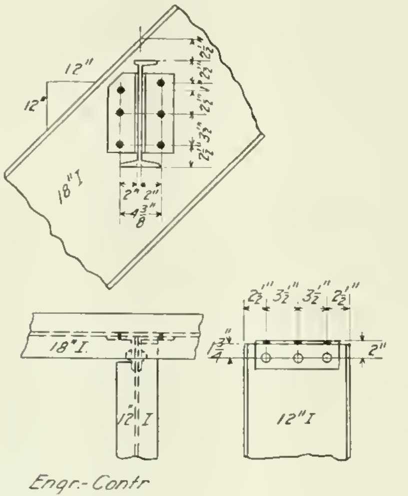


Fig. 5.

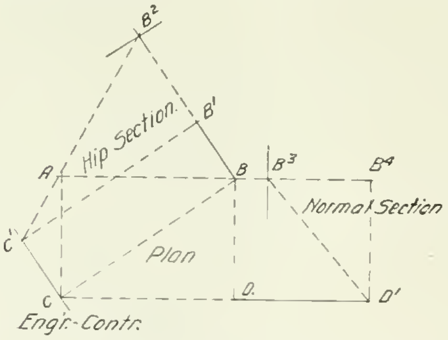


Fig. 6.

In working up a roof of this sort, a careful plan like this needs to be made. First locate the finished roof lines; then by finding out what material it is to be covered, the clearances necessary can be determined. Dimensions locating every detail can only be found as sketches of the joints are worked up, but all the important ones must be decided upon at the start. Then, after all the shop drawings are completed, this section drawing can have its final marks, dimensions, etc., put on. It may be noted that the dimensions marked *A* in plan are not usually given in this kind of work, as the anchor bolts are set after the material is in place.

It is hardly probable that such a roof as this would be called for, in ordinary work, on account of the cost. In a roof with the span of beam much larger, and the amount of material greater, there would be a better proportion of weight to work, bringing down the cost. This particular roof was a wing to a very large structure and received attention on that account. The actual cost of drawing alone was found to be 2¼ cts. per lb., and, if you add a proportionate amount for shop handling and the cost of raw material, this roof would require a very high price put upon it, or be out of the question.

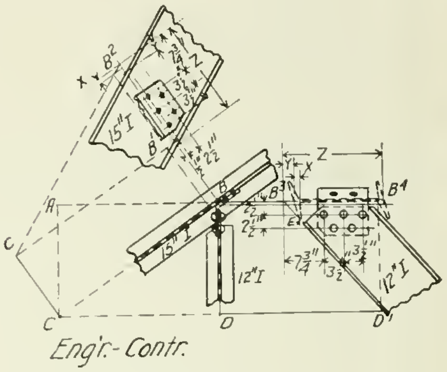
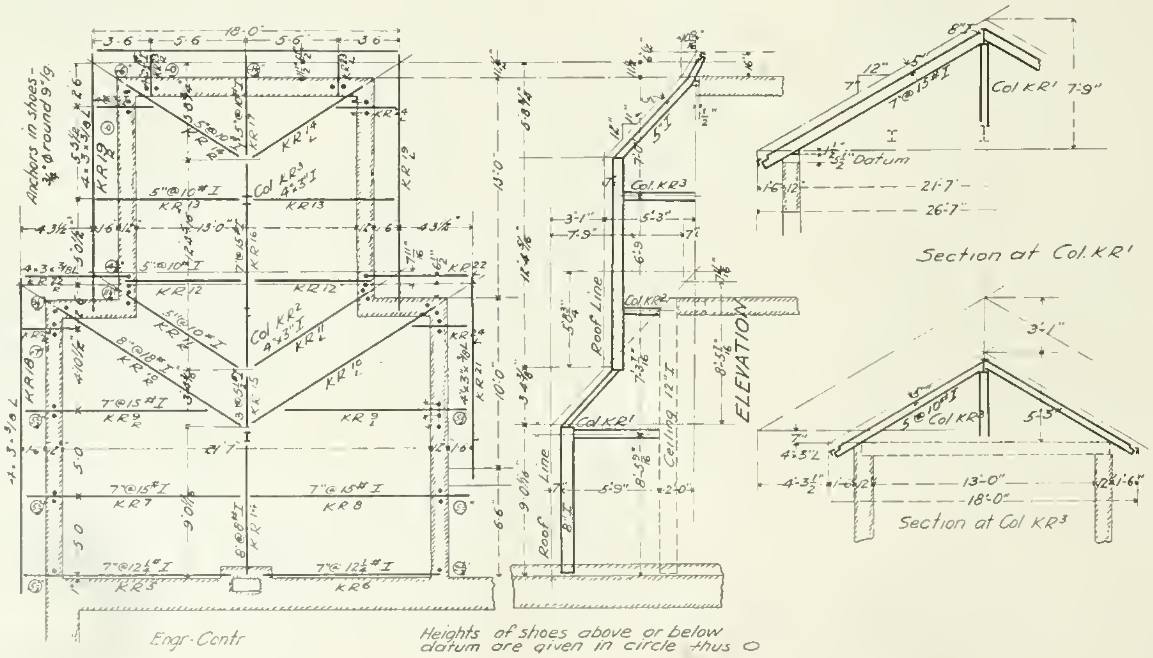


Fig. 7.

Perhaps no one point can cost more to a drafting department than a change of only a single main dimension, after the sketches and drawings are completed; because it not only means the remaking of the joint sketches (to look out for clearances, change in connections, etc.), but also the probable uselessness of the shop drawings upon which weeks of expert labor have been spent. If the material has been manufactured it is very difficult to make it fit



Heights of shoes above or below datum are given in circle thus ○

Fig. 8.

elsewhere. Architects and structural engineers as a rule do not realize the importance of first measurements on a job of this kind, for, of course, in the old-style wooden structure the carpenter only had

(b) Plot next the normal section with its double lines and then the hip section.

(c) In the normal section find a true view of hip beam (shown dotted) by the method explained in Fig. [illegible]

length h, which is the vertical rise of the point at one end above a point on [illegible] at the other end. Transfer this horizontal distance and the vertical rise to normal section and the level is obtained.

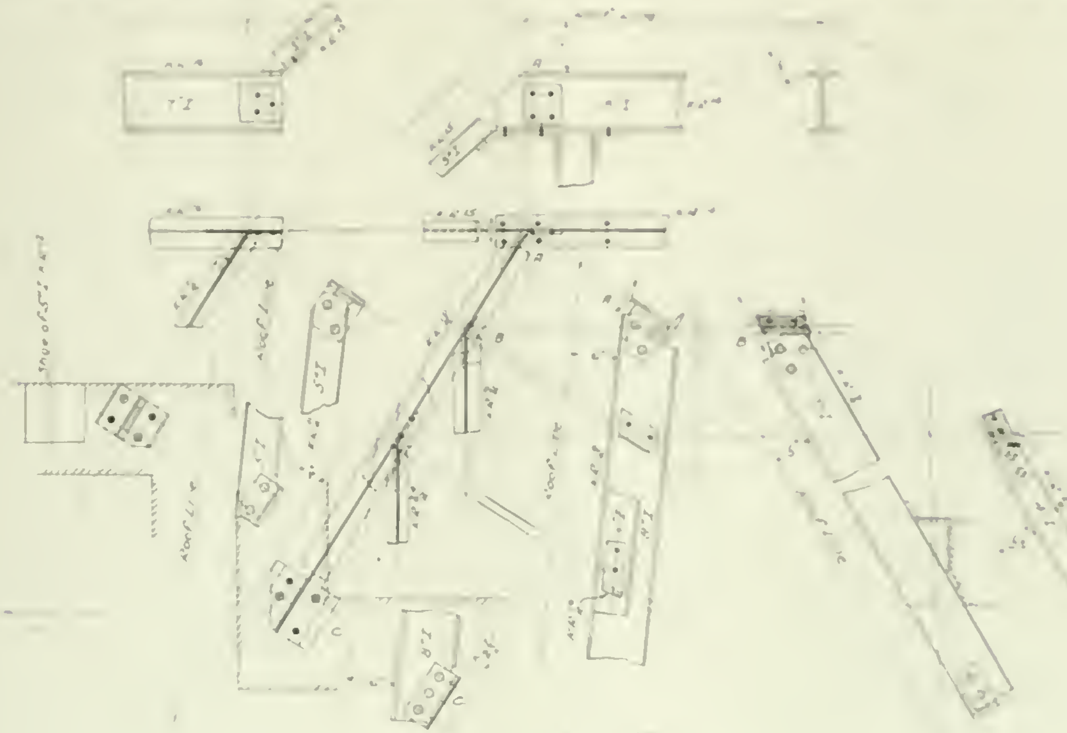


Fig. 9.

to saw a piece off or nail a strip on to make a good fit.

Figure 9 shows how these joints are worked up on paper in the drawing office as a preliminary move towards the finished shop drawings. The ordinary draftsman who is accustomed to work in a laborious manner, one joint at a time, may find the sketch somewhat confusing, but, with just a little looking into, it will be found to become very simple and certainly a great saving in time and office material. When single joints are sketched the laying out of the angles has to be done each time, while by combining them, one plotting does the whole sketch. Another nice point to notice is that the hip connections are worked up in order, thus facilitating the making of shop drawings.

At A the connection of hip to rafter is shown in its various views; at B a rafter connecting to hip similar to the one explained fully in Figs. 6 and 7, and at C the hip shoe. The valley KR_{I} [illegible], the ridge beams KR [illegible] and rafter KR_{I}, KR_{I} are also shown.

The sketches show, throughout, a clearance of beam below roof line.

Figure 10 shows a rather complicated connection to the hip beam marked KR^{14}_{R} in erection plan Fig. 8. The secondary slope which the roof takes at this end, causes the I-beam KR_{R} to frame into the hip at such a level that the only means of connection will be to the bottom flange.

(a) Starting with the plan, line AB, which is the center line of the hip web, and CD the center line of I-beam web.

(d) To find the level X of the connecting angle in relation to the level of rafter— Plot in plan any horizontal distance (12X) on center line of I-beam I and find

(e) To find the bevel of square connecting that angle. Plot a horizontal distance 12-d in plan. Find in the hip section the vertical rise AH between the [illegible] points

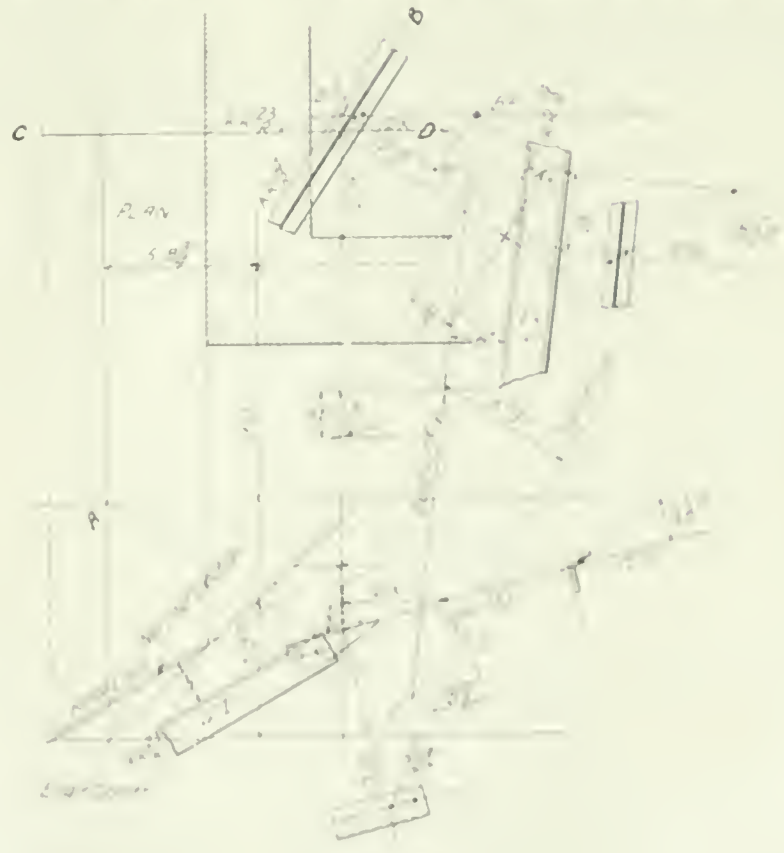


Fig. 10.

Now AH is the vertical rise, but what is wanted is a rise square with angle. So plot AH and a line square with angle and we find the required distance A. It remains to transfer 12″A and A to section, which is taken through angle, and bevel is obtained.

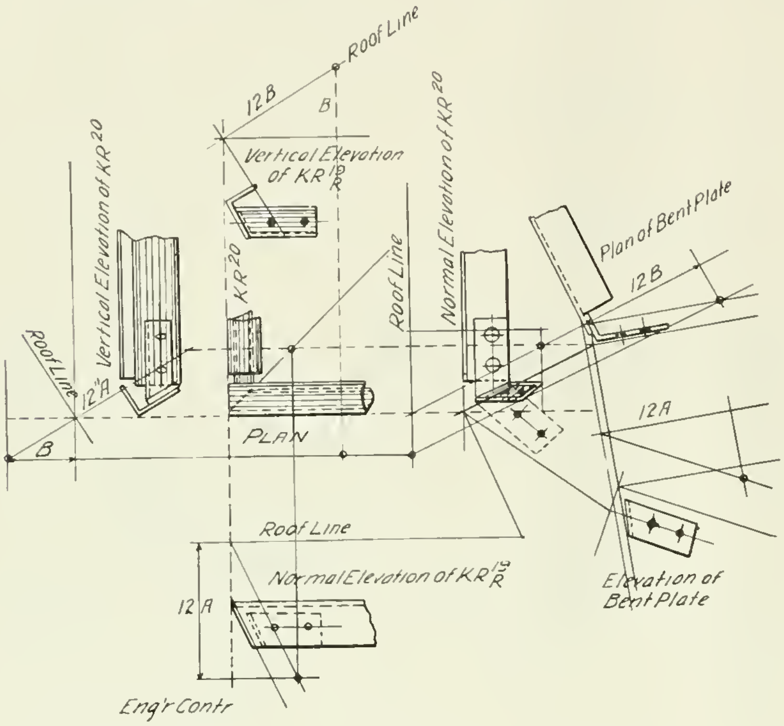


Fig. 11.

(f). To find the skew of holes in bottom flange of 5-in. I hip: In plan draw a line B^1B^2 at a distance 12B from, and parallel to 5-in. I. Draw a line B^3B^2 parallel to 4-in. I. B^2 is the intersection of these two lines and B^1 is a point square from intersection B^3. It can be seen that the line B^1B^2 is the horizontal projection of B which is one side of bevel, and all that remains to be done is to transfer the assumed distance 12B to plan of flange and bevel is obtained.

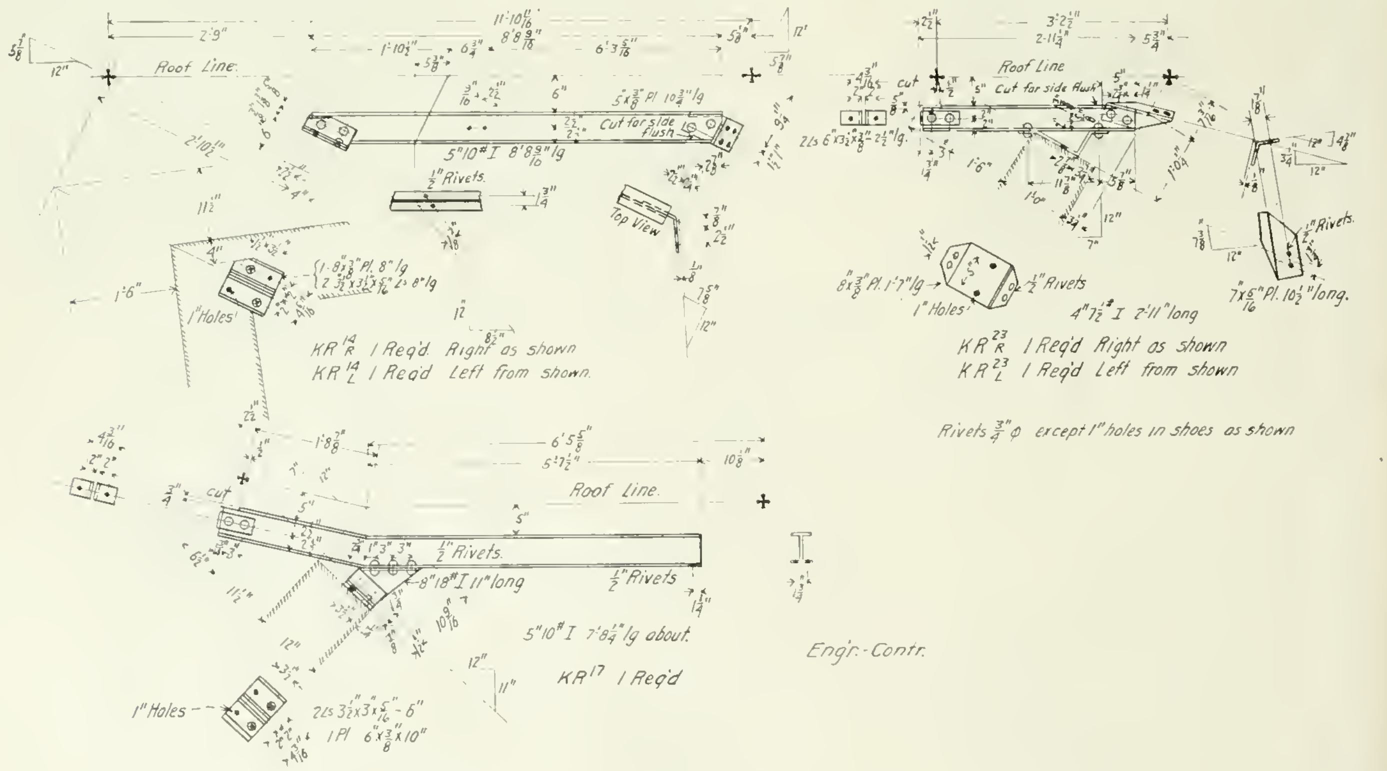


Fig. 12.

(g). The skew of the holes in the connection angle which matches the holes in flange of 5-in. hip I will be the same as B because the flange and the angle are in the same plane.

Figure 11 shows the connection between the eave angles at the corners, and is quite a different proposition from any that have been taken up so far. Both steel angles are normal to roof slope and require to be connected with two rivets in each side of a bent plate. To find skew across bent plate, start with vertical elevation of KR^{20} and mark a point at distance 12A. Project this into plan and then into a normal elevation of KR^{20}, where skew is found in a similar way to previous examples. To find bend in bent plate, start with a point at a distance 12B in vertical elevator of $KR^{19}R$, trace this into plan, normal elevation and plan of bent plate. Here the bevel is found. The skew across other leg of plate should be the same as that found for the first leg.

Figure 12 is a shop drawing of three different pieces in the roof, and shows the method of locating rivets, etc. The roof line is first drawn in, and the beams located at their proper distance below same; then the shoe, connecting holes for rafters, and the bent plates can be scaled directly from the large sketches. The rivets are located only in two directions and these are not always spaced along the beam nor even do they start from a point on the beam. The method shown would not be allowed in some shops, yet it is certainly the best manner of location for the office, because the pieces which frame into one another have respective dimensions match up. Another run of figures, locating rivet to rivet along web, causes a tremendous amount of extra labor to make them match exactly. The manner in which the drawings should be made depends entirely upon what the shop is accustomed to use.

MORE COMPLICATED CONNECTIONS.

The next figures introduce connections which are more difficult because another angle enters into the problem. Figure 13 shows a rather peculiar connection which was used in a certain building to see if it would be cheaper to cut beams clear of all copes, cuts, etc., and allow bent plates to make the connection. In a shop where beams can easily be sawn on a skew, and have copes and flanges cut, the cost would be much greater when this method is used. To make the connection stiff enough, there will be required a greater number of rivets in web and two connection plates [illegible] each case. The manner of connection [illegible] field bolts or rivets needs to be carefully looked into, and Fig. 11 shows a bolt being inserted into the connection. [illegible] of plating this connection will now be explained in detail.

Purlin Normal to Roof [illegible] *Hip Beam Vertical*.—[illegible] is proposed to find the various skews required and then to sketch a 7-in. I purlin which frames into a 15-in. I beam when said hip beam is 2 ins.

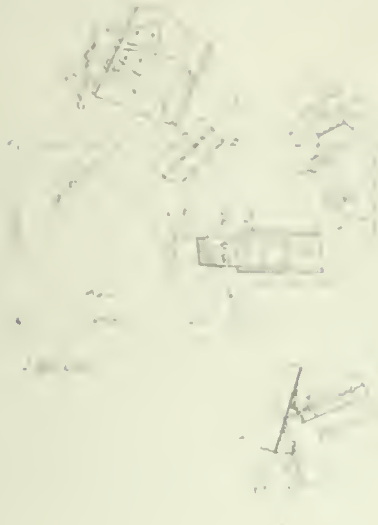


Fig. 13.

clear and said purlin 3 ins. clear of roof line.

(a) Lay out a plan *ABCD* showing hip *CB*.

(b) Erect a normal section of roof *DBB'*.

(c) Erect a hip section, *BB''* being the same height as *BB'*.

(d) It is required to plot 15-in. I 2 ins. clear of roof, therefore in plan show flange, in normal section plot a line 2 ins. clear of roof (2 ins. is marked *x*). Now as 15-in. I flange sticks up and down through normal roof, find this rise and fall in hip section. Half of flange has a vertical rise of *R*. Plot *R* in normal section, thus finding required vertical height *R'* for 15-in. I top flange, and by transferring *R''* to the hip section the 15-in. I can be plotted correctly.

(e) It is required to find the line of intersection of 7-in. beam with hip, therefore draw a line *B'M* perpendicular to normal slope through 7-in. I (say 12 ins. long) and find point *M* in hip section by projecting lines through plan and transferring vertical height *X*. Then *B''M* is required line.

(f) It is required to plot purlin section through its center line, so that purlin skew may be found. Draw a line *FF* parallel to *BB*, representing apex of section, and by finding vertical trace of point *M* in purlin section, the required line *FM*, which gives the proper skew, may be drawn.

(g). It is required to plot a purlin [illegible] section to find skew at right angles to purlin skew. Draw any line [illegible] at right angles to purlin skew representing [illegible] of 7-in. I purlin in hip section. The angle that is wanted should give the relation of 7-in. I purlin web with 15-in. I [illegible]. Take a point in the 15-in. I [illegible] distance from intersection [illegible] perpendicular to *B'M*. Trace the point through the various views to the purlin [illegible] section. The required point will be [illegible] where in this line and at [illegible] distance away from intersection. [illegible]

[illegible] *J* [illegible]. The [illegible] proper skew.

[illegible]

Reasoning [illegible] may be worked out in the usual manner.

Figure 15 shows the [illegible]

Fig. 14.

connection, which appears much neater and is more simple in every respect. In this case the truss chord to which it connects is dropped below the purlin and the gusset plate extended to take the field rivets. A line along back of truss angle is used as the intersection line.

Figures 16 and 17 illustrate a curved mansard roof. Figure 16 shows a corner of the roof in plan and elevation, and Fig. 17 a detail drawing of the hip and valley marked on plan. On this large structure

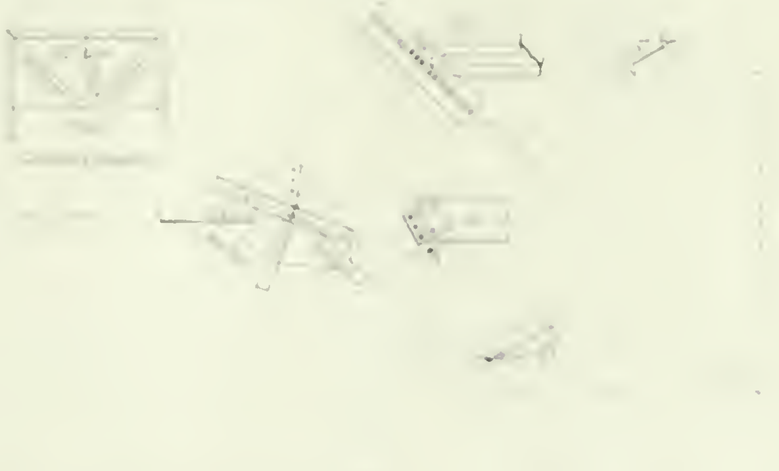


Fig. 15.

[illegible]

British Methods of Competitive Bidding on Building Work.

[illegible]

[illegible]

The [illegible]

During the eighteenth century there was a system practised whereby the architect employed would furnish his client with an estimate of the cost of the work, upon which estimate the architect would obtain advances of money and himself make contracts with tradesmen for the performance of the work in the several trades. At the completion of the building the architect would produce these contracts, together with the receipts, and arrive at a settlement with his client, the latter frequently paying the architect something in excess of his commission if the contracts were less than the original estimate.

As in the beginning of the nineteenth century, the building trade seemed likely to fall into a few hands, it attracted the attention of men possessed of capital, and shortly afterward a system of [illegible] contracts came into vogue. They now became more directly interested in the subject.

[illegible]

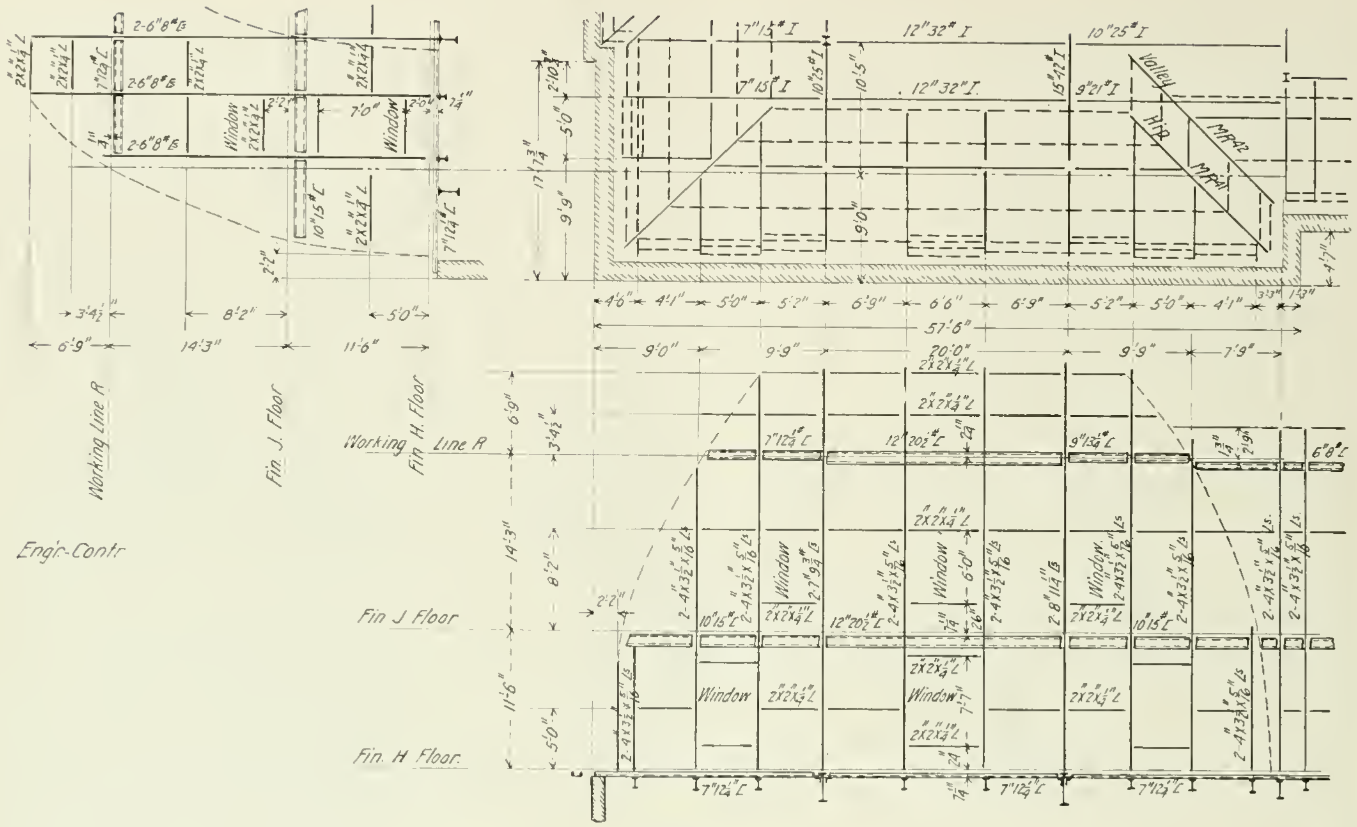


Fig. 16.

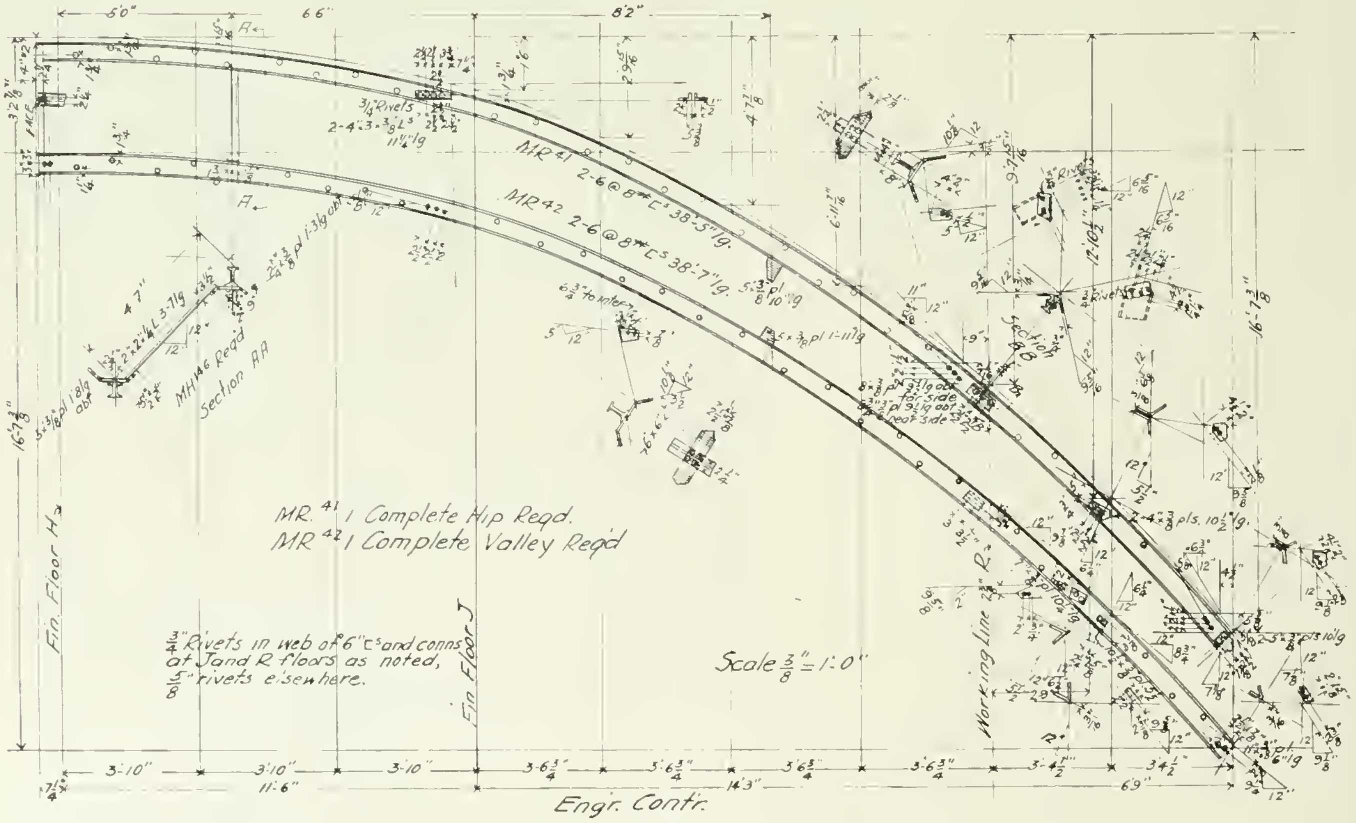

MR 41 2-6@8# ⊏s 38'-5"lg.
MR 42 2-6@8# ⊏s 38'-7"lg.
MR. 41 1 Complete Hip Reqd.
MR. 42 1 Complete Valley Reqd
3/4" Rivets in web of 6" ⊏s and conns at J and R floors as noted, 5/8" rivets elsewhere.
Scale 3/8" = 1'-0"
Fin. Floor H
Fin. Floor J
Working Line R
MH 46 Reqd
Section AA
Section BB
Engr. Contr.
11'-6"
14'-3"
6'-9"
16'-7 3/8"

Fig. 17.

total arrived at which gives some idea of the cost of the proposed building. At completion of the whole of the work is measured by the surveyor, priced according to the schedule, and the exact cost ascertained.

A somewhat similar method of competitive tendering is sometimes adopted in England for large buildings when it is possible for the foundations and basement to be proceeded with while the drawings for the superstructure are being prepared, and other preparatory work performed. A schedule embodying, as far as may be seen, all the principal items of the work in question, is drawn up by a surveyor, and copies sent to builders desiring to tender. The surveyor reports to the architect upon the prices which the builders have attached to the various items, and though a total sum cannot be stated, as the quantities are not indicated in the schedule, some idea of the respective tenders may be gained, and the builder offering the most favorable quotation is appointed to carry out the work.

While discussing schedules it may be interesting to mention those issued by British public bodies such as H. M. Office of Works and the War Office. The former has under its control the Royal Palaces and buildings used for Post Office, Inland Revenue and other purposes. These schedules are most complete and inclusive and bear reference to practically all the items that may be met with in building work. They name a price for each item, and contractors are invited to tender at a percentage above or below these prices, as they please. This method is not employed for the erection of new buildings to any great extent, but mostly for the hundred and one matters connected with their upkeep after erection. Periodical accounts are rendered by the contractor who arrives at his charges by measurement, the items being priced according to his tender upon the schedule. The measurements and prices are checked by the surveyors employed by the authorities.

A further system of competitive tendering is sometimes, though rarely, adopted by some architects with advantage in cases in which the extent of the work is not at first determined or in which the plan of the building is liable to alteration at the whim of the client. A contractor for the whole of the work or for one or more particular trades is invited to state the percentage of profit for which he is willing to undertake his portion of the building. The percentage of profit has to cover all office and working expenses, and the provision and maintenance of scaffolding and plant, these items not appearing in the accounts. It is usually considered that these expenses, or establishment charges, as they are called, come to about 8 per cent on the cost of the building, though the present writer has known a case in which a large building was erected upon this system and in which the contractor accepted this percentage to cover his establishment charges and provide his profit. From 12 to 15 per cent is frequently charged. The questions of workmen's railway fares, should the job be situated at a distance from an industrial center, and of other similar outlays are matters of mutual agreement. The clerk of works engaged on the building keeps an accurate record of the time spent by the several workmen and of all the material coming on to the job, and he makes a return of these weekly either to the architect, or preferably, to a surveyor who compares it with the corresponding accounts rendered by the contractor. The contractor is required to submit receipted invoices for all materials bought for the job, these being likewise subject to the scrutiny of the surveyor. The books are also open for inspection by the surveyor when desired. Such portions of the work as cannot be invoiced in this way are either charged for by the contractor [illegible] and valued by the surveyor. One objection to this system, common also to the systems before described, is that the cost of the work is not known before the building is commenced, and that, to a certain extent, the building owner is in the dark as to what his house is likely to cost. A further objection is the temptation it [illegible] the contractor to keep a [illegible] expenses and to employ [illegible] can be set to work with advantage [illegible] to falsify the time and material sheets. It will be seen that the larger the wages and the higher the cost of materials the greater is the profit. Given, however, an honest and capable contractor—[illegible] are many—and an experienced and careful clerk of works, this [illegible] result in good workmanship [illegible].

But by far the most usual method of obtaining a competitive price for the erection of a building is by the supply of detailed bills of quantities of all the labor and materials required to complete the job in accordance with the architect's drawings. The practice of supplying quantities has been steadily growing until only small buildings are now tendered for without them. Many good builders decline to tender without quantities. It has been recently announced by the heads of two large British Government departments, namely, the Office of Works and the War Office, that quantities will as far as practicable be provided for jobs exceeding £500 in cost. In some instances the quantities are taken off [illegible] the architects' own office, sometimes by himself (which argues a considerable amount of spare time) and sometimes by an assistant more or less qualified to perform this duty. The most generally recognized procedure, however, is for the architect to appoint a quantity surveyor who is in practice on his own account, or, at all events, to use his influence with his client for the appointment of the surveyor. By this means the quantities are prepared by a man who is familiar with the architect's wishes and custom. In this case the surveyor is commonly paid through the contractor, a sum for this purpose having been added to the amount of his tender. In the case of work for municipal and other public authorities the committee responsible for carrying out the scheme frequently appoint a surveyor themselves, and pay him direct.

The quantity surveyor's charges of course are in addition to the fees paid to the architect. It will be understood that there is less work, proportionately, in preparing quantities for a large building than for a smaller one of similar nature and schedules of charges have been drawn up to meet this difference. That of the Quantity Surveyors' Association of Great Britain is perhaps the most representative and is as follows:

For buildings such as the following	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Workhouses, Hospitals, Asylums, Warehouses, Dwellings, Tramway Depots.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible] Buildings, Town Halls, Libraries, [illegible] Stations.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

[illegible] should appear in the bill. The quantity surveyor is able to render [illegible] the work of the estimator [illegible] the liability to error. The [illegible] of disputes between architect and contractor has sometimes been attributed to the work of the surveyor [illegible] tempted to recoup himself for an error in estimating by the use of inferior materials or workmanship.

The question may be asked as to the relation which the quantities bear to the contract between owner and builder. To this question there are three answers. Many bills of quantities, particularly, it is to be feared, among those prepared by the less efficient surveyors, include a clause similar to the following:

> The bills of quantities are not guaranteed to be accurate, though great care has been observed in their preparation, and they are believed to be thoroughly [illegible]. The contractor whose tender is accepted will be expected to satisfy himself as to the accuracy of the bills of quantities before signing the contract and any claims for [illegible] must be preferred before signing the contract. After the contract is signed the contractor is to be wholly responsible for any errors that may be afterwards discovered in the bills of quantities.

In this case the quantities have no relation to the contract save in so far as they form a schedule for any variations that may be made upon the original scheme. It is difficult to defend a system of this kind, by which it is supposed that the work that has taken the trained surveyor perhaps a month to perform may be checked by a builder in the brief interval between the acceptance of his tender and the signing of the contract. Were he able to do so it would seem almost unnecessary to have employed a surveyor at all. Of late years, however, it has become more and more the custom either for the surveyor to guarantee the accuracy of his quantities and to [illegible]

There is no [illegible]

[illegible]

while the contractor is paid for all he does, and the owner is not called upon to pay for work that is not executed.

Moving a Contractor's Plant Over a River on Ice and Data on the Maximum Load That Ice Will Sustain.

In view of an apparent lack of data concerning the maximum load that ice will sustain, the following account of the moving of a contractor's plant across the Hudson River on the ice should prove of interest. The plant was transferred across this river at Stillwater, N. Y., in order to begin work on Lock No. 4 of the Champlain Canal of the New York State Barge Canal. This lock is included in Contract No. 68, for which the Shanley Morrisey Co., of New York City, are the contractors. An account of this crossing is in the April issue of the Barge Canal Bulletin, and the following matter has been taken from that issue:

The lock is to be built on the east side of the Hudson, opposite the village of Stillwater. The nearest railroad station on the east is at Schaghticoke—six miles away—but on the west a trolley line is close to the river's bank. The high-way bridge at this point is an old structure and also too light for heavy loads. To avoid the necessity of hauling their plant overland for six miles, the contractors conceived the idea of delivering the machinery by the trolley on the west bank and taking it across on the ice. The heaviest single piece was a Model 60 Marion steam-shovel, weighing about 70 tons when in working order. This could be stripped to about 45 tons by removing the boom and dipper, which weighed some 15 and 10 tons, respectively. There were also three Porter locomotives, weighing 18 tons each, which could be stripped to 15 tons. In addition the plant contained the usual hoisting engines, dump-cars, drills, etc., some pieces weighing as much as 12 tons. This machinery was delivered at Stillwater on January 12.

In the vicinity of Stillwater the river freezes ordinarily to a depth of about 18 in., but during the past mild winter it was only about half that amount. To increase the thickness of the ice, the contractors devised the plan of cutting holes and flooding the surface by pumping water upon it. By this means a thickness of from 10 to 14 ins. was obtained.

The plant was unloaded at Stillwater in January, and the contractors waited for about a month, but then, as it seemed too late in the season to expect any protracted cold spell, it was determined to begin operations. Moreover, on Feb. 4 there was a threatened thaw, and lest they should lose all for which they had been waiting, they decided to proceed with all possible speed. Accordingly they placed their tracks in position, working all night, so as to be ready for transporting the machinery on the next day.

Meantime, on the afternoon of the fourth, a trial load weighing about 15 tons had been run out upon the river. The ice seemed to bear this weight safely and the contractors felt confident of success in transporting at least the greater part of their plant. It was especially desired, of course, to get the steam-shovel across and to put it at work excavating, and the long and expensive labor of carrying this machine overland had furnished the chief reason for waiting for the formation of this ice bridge, but it had been decided from the first to test the ice with the locomotives before risking the heavier and more costly shovel.

For spreading the weight over a wider area, 8 by 16-in. yellow pine timbers, 24 ft. long, were placed beneath the narrow-gage railway. The river at Stillwater is 1,000 ft. wide and these long timbers were used for about four-fifths of the distance across from the east bank, being spaced 15 ft. apart. In each space two 8-in. ties, 8 ft. long, were placed, thus making distances of 5 ft. between the supports for the track. The plant was to reach the ice from a dock on the west bank. To sustain the shock of this abrupt decent, the ties and long timbers were spaced much closer at this place. The supply of 24-ft. timbers was not sufficient for the whole distance, and so, near the west bank, there was a stretch of 150 ft. in which the track was supported by the 8-ft. ties alone, but spaced 2½ ft. apart.

Early on the morning of the fifth the contractors began pulling over their machinery, the lighter loads being taken first. A hoisting engine had previously been hauled across and this was placed on the east bank. A cable 1,000 ft. long, stretching from this engine to the opposite bank, was used to pull over the desired loads. By taking several turns with this cable around a spool on the drum shaft the various machines could be transported while the men were on the shore, and it was not necessary to risk the life of someone upon the ice when the heavy loads were being carried. Moreover, when once started, these burdens could thus be quickly hauled across.

The greatest strain came in the afternoon, when the three locomotives were being carried over. To obtain data on the supporting power of ice, the engineers in charge of this contract had taken a series of levels upon the track. Then by fastening a leveling rod to a locomotive the fluctuations of the ice surface could be determined while the load was in transit. It was thus learned that the ice did not sink quite so much as appeared to the eye, for the surface seemed to take a great billowy motion as the locomotive advanced. The levels showed that the ice sank under the weight about four inches, on the average, a maximum of some 6 or 7 ins. being reached. It took about four minutes to haul over a single locomotive. The wave-like undulation of the ice beneath it may be likened to the conditions which exist when a skater goes rapidly over a thin surface. There was also a shattering of the ice and numerous cracks were opened.

After the locomotives were taken over, the boom and the dipper of the steam-shovel were transported separately and the work continued until two o'clock the next morning before all the machinery except the steam-shovel was moved. This did not get so far as the ice. After bringing it close to the river, it was finally decided that it was not safe to make the attempt. Then, after waiting for several days, during which there was no indication that the ice would become stronger, it was determined to move the shovel by the overland route, and it was accordingly taken to Schaghticoke and carried over the highways for six miles, a task that involved about a week's labor. Fortunately for the contractors, while the shovel was being moved, there was almost no snow upon the ground, but a thin layer of ice covered the surface. It was thus possible to haul the rails easily and to lay the track without ties, a few flat iron rods holding the rails together and in position. The machine was moved for about $100 a mile.

Although it is not possible to say that the ultimate load for ice under the existing conditions was reached, yet it would seem that the tonnage taken was near to that limit. The ice in the vicinity of the track was badly shattered and fissured, somewhat as a piece of thin ice or a pane of glass would be from a severe blow. The cracks in general did not extend many feet beyond the timbers and ties, but in some instances they reached to a distance of some 40 ft. away. The ice may be described as simply of ordinary quality, probably not so strong as a clear, quickly-frozen ice, although the contractors had taken the precaution of keeping the snow removed from the site of the crossing, so that it was not what is known as snow ice. A thaw had been in progress during the day and probably the ice was weaker than on the preceding day when the test load was carried. The engineer in charge of the residency, having witnessed these operations, states that, with ice in the condition it was at the time of the crossing, the maximum load of 15 tons appeared to be about all that 10 ins. would safely stand.

Steam shovels in April removed 2,137,861 cu. yds. on the Panama Canal, of which 2,083,560 cu. yds. were "work," and 54,301 "plant," excavation. In the Central Division the shovels excavated a total of 1,798,454 cu. yds., comprising 1,687,766 cu. yds. from the Canal prism, 74,402 from the Obispo Diversion, 15,688 taken from the prism and then dumped back for levee purposes, and 20,598 excavated by hand. The following table gives a comparison with other high monthly records in this division:

Date—	Prism.	Prism and Outside.
March 1908	1,540,497	1,615,118
October, 1908	1,531,409	1,598,981
February, 1909	1,546,008	1,644,636
March, 1909	1,966,294	2,065,827
April, 1909	1,722,442	1,798,454

The high record for the month was made by shovel No. 223 (90-ton at work in the Culebra District,) which took out 51,184 cu. yds. of earth in 26 working days, an average of 1,969 cu. yds. per day. The best record for shovels in the 70-ton class was made by No. 122 in the Bas Obispo District, which removed 35,053 cu. yds. of rock and earth in 25 working days, an average of 1,402 cu. yds. per day. The record for a single day's excavation was broken on April 8, when 57 shovels took out 78,559 cu. yds, an average of 1,378 cu. yds. per shovel. The best day's record for one shovel during the month was on April 12, when No. 266 in the Culebra District excavated 3,340 cu. yds. On April 6, the 18 shovels working in the Culebra District broke all previous records for districts, removing 28,350 cu. yds., an average of 1,575 cu. yds. per shovel.

The Brooklyn Engineers' Club has taken possession of new quarters, at No. 117 Remson street. The cost of the building, which was formerly the old Nesmith mansion, was about $30,000. Several thousand dollars more are being expended to remodel the building and make it an up-to-date clubhouse. The building is three stories high. There is a basement, in which the caretaker will live. The auditorium, with seats for 150 persons, and a dining room, with accommodations for about twenty persons, take up the parlor floor. In the auditorium the members will hold their meetings and the room will be rented to kindred organizations for meetings when the club does not need it. On the second floor are the library, the office of the secretary and the smoking room. The top floor will be divided into five bedrooms for the use of members.

Cost of a Brick Manhole, Flush Tank and Laying Pipe Sewer.

The following data relate to the construction of a brick manhole, a brick flush tank and the laying of a section of sanitary sewer at Columbus, Miss. The work was constructed by the [illegible] own estimate of costs.

Brick Manhole.—The manhole was 4 ft. in diameter and 6½ ft. deep; it was of the "churn pattern." Its cost was as follows:

1,000 hard brick at $6.00 delivered	$ 6.00
7 sacks Portland cement at [illegible] delivered	[illegible]
1 yd. sand delivered	[illegible]
Ring and cover, [illegible] lbs. at $[illegible] per 100 lbs.	[illegible]
[illegible] step irons	[illegible]
Hauling iron	[illegible]
Digging hole in brick clay	[illegible]
Piping	[illegible]
Mason, 8 hours at [illegible] cts.	[illegible]
Helper, 8 hours at 12½ cts.	1.00
	$[illegible]
Engineers' estimate of cost	[illegible]

Brick Flush Tank.—The flush tank was 4 ft. in diameter by 5 ft. deep. Its cost was as follows:

[illegible] brick at $6.[illegible] delivered	$ [illegible]
9 sacks Portland cement at [illegible] cts.	[illegible]
1 load sand	[illegible]
1 load gravel	[illegible]
Ring and cover, [illegible] lbs. at $2.40 per 100 lbs.	[illegible]
7-in. automatic syphon	[illegible]
Freight	[illegible]
Drayage	[illegible]
Drain pipe	[illegible]
Digging and filling (sand)	[illegible]
Mason, 9 hours at [illegible] cts.	[illegible]
Helper, 9 hours at 12½ cts.	1.13
Total	$[illegible]
Engineer's estimate	[illegible]

Laying Sewer.—The sewer was 1,613 ft. long, of 8-in. terra cotta pipe. The sewer pipe was furnished by the city, delivered on the job, so that the following is the cost of laying only.

Four manholes and one flush tank were also constructed, but these were paid for separately and their cost is not included in the figures below. The average depth of the trench was 6½ ft. The work was completed in 11 days of 10 hours each. The cost was as follows:

	Total	Per lin. ft.
Labor, 1,099½ hours opening trench, laying and back filling with shovels, at 15 cts. per hour	$16[illegible]	$ .1[illegible]
Wiping joints, cutting [illegible], 143 hours at 1[illegible] cts.	[illegible]	[illegible]
Superintendence, 11 days at $[illegible]	7[illegible]	[illegible]
Cement, 12 sacks at 50 cts.	[illegible]	[illegible]
Sand, 3 loads at 50 cts.	[illegible]	[illegible]
Total	$2[illegible]	$ .1[illegible]

We are indebted to Charles [illegible] Wood, C. E., Columbus, Miss., for the above information.

LETTERS TO THE EDITORS.

The Theory of Economical Road and Street Design and Location.

Sirs: Referring to the articles "The Theory of Economical Road and Street Design and Location," running in your paper since April 14, 1909. These articles [illegible] to show that the reduced cost of hauling farm produce to market on a paved road will justify the cost of the pavement. The proof offered rests on three assumptions that will not bear [illegible] scrutiny:

1st. That the resistance of an earth road is twice as great as that of a macadam road.

2nd. That the maximum [illegible] load will be hauled and the number of loads on earth be reduced one-half and that the cost per ton mile will drop from [illegible].

3rd. The assumption of a system of parallel roads two miles apart.

Considering these in order:

1st. The [illegible] of earth and of macadam [illegible] the rate of 2 [illegible] road. Roads are rarely level. Grades [illegible] more frequently the factor that limits the team load [illegible] of the road surface.

2nd. When the grade resistance equals that of an earth road surface the actual ratio of total resistance between earth and macadam is as 4 [illegible] and the macadam permits an increase in wagon load of but [illegible] per cent instead of 100 per cent. When the grade resistance is twice the surface resistance the increase is but [illegible] per cent. The wagon load would not, therefore, be doubled, and the conclusions of the [illegible] require radical revision. Apart from the question of road resistance the assumed maximum macadam load will rarely be hauled because most farm products are of such unit weights or quantity that they cannot be put onto a farm wagon in one load. Moreover, by choice, necessity or convenience farmers take a considerable part of their produce to market in light vehicles incapable of carrying over two tons in one load. Therefore grade resistance, character of tonnage and convenience combine to render impracticable, if not impossible, the attainment of an average load of four tons. It is improbable that a change from earth to macadam would increase the load more than 25 per cent.

3rd. Parallel paved roads two miles apart are inadequate. Paved cross roads are equally necessary. Indeed a rectangular system of roads two miles apart would not meet the requirements of the theory which assumes that all produce is hauled from farm to market over paved road all the way. Paved roads one mile apart in both directions, or on the four sides of every section of land, are the least that will satisfy the assumption of the theory. It appears, therefore, that the estimated mileage and cost of the necessary pavement are but one-fourth as large as they ought to be.

The theory fixes the resistance of macadam as the ruling and limiting grade on which a 4-ton load can be hauled. It is evident that if a section of earth road is [illegible] the limiting grade is doubled and the load is reduced to 2 tons.

[illegible] what would happen when isolated roads in one direction [illegible]. The [illegible] from the farm [illegible] and [illegible] the market [illegible] would be hauled [illegible] and the load would be [illegible] per ton mile [illegible] per ton [illegible] that have been expended on the [illegible] paved road.

A [illegible] of [illegible] acres of land will not produce for market [illegible] of [illegible] tons [illegible] year [illegible] the [illegible]. The [illegible] of [illegible] $[illegible] on [illegible] road [illegible] saving for the [illegible] of $[illegible] on a [illegible] road [illegible] of $[illegible].

[illegible] that [illegible] the [illegible] road will save $[illegible] [illegible] these [illegible] assumptions. The [illegible] have [illegible].

[illegible] that [illegible] to [illegible] road [illegible] the [illegible] of [illegible] from [illegible] to [illegible] of [illegible] road [illegible] $[illegible]. The [illegible] of [illegible] at a [illegible] rate of interest [illegible] of [illegible] $[illegible] the [illegible] $[illegible]. The [illegible] and [illegible] the [illegible] of [illegible] road [illegible] for [illegible] Yours [illegible],

J. L. CAMPBELL.

El Paso, Tex., May 18, 1909.

[The serial article [illegible] to justify the [illegible] of all roads, as Mr. Campbell appears to think [illegible] upon the three assumptions that Mr. Campbell [illegible] will not bear analysis. However, the first assumption, that a macadam road will enable a team to haul double the loads hauled over [illegible] grades. Mr. Campbell [illegible] that it will do so on a level road but says that we have neglected to consider the effect of grades. We had [illegible] for that particular phase of the subject is fully considered in our issue of May 19, which Mr. Campbell had not seen at the time of writing his letter.

Mr. Campbell makes the common error of assuming that when the grade resistance equals the road resistance the cost of the load must be cut in two, which is true of a railway but is not true of a wagon road, for reasons set forth in our May 19 issue.

We have made certain assumptions as to wagon loads partly for sake of illustration. The principles deduced do not rest upon the exact truth of any of these assumptions.

Our issue of May 19 also answers Mr. Campbell's objection as to all wagon loads not being full loads.

Our illustration of parallel paved roads 2 miles apart is not an assumption of general conditions but [illegible] an illustration for a particular case, but it is open to the objection raised. Actually by such wide spacing of paved roads the wagon loads would be [illegible] that could be hauled over an earth road to get to a paved road. Loads hauled long distances on macadam roads are not limited by short stretches of earth roads preceding the macadam, for [illegible] reason that moderate grades [illegible] length do not [illegible] the load [illegible] hauled by teams [illegible] capable of exerting [illegible] the average tractive force for short periods of time, with intervals of rest. [illegible] in [illegible] the [illegible] wagon road [illegible] from the farm over a very bad earth road [illegible] a paved road on which the team's tractive [illegible] with the loads [illegible].

Mr. Campbell [illegible] the [illegible] roads [illegible] will [illegible] $[illegible] a [illegible] at [illegible] per [illegible]. The [illegible] have [illegible] roads [illegible] Mr. Campbell [illegible] per mile [illegible] wide and [illegible] Mr. Campbell's [illegible] if the paved roads [illegible] with [illegible] double [illegible] the [illegible] only a [illegible].

We are glad to have [illegible] that [illegible] road [illegible] economical [illegible] or [illegible] and [illegible] that [illegible] of [illegible] road [illegible]. We [illegible] that [illegible] road [illegible] that it will [illegible] a [illegible]. One of our [illegible] develop a rational method of locating and designing roads, to take the place of the common plan of adhering to fixed "standards" and antiquated precedents.

We agree with Mr. Campbell that the motor car is fast rendering necessary something better than a macadam road surface, at least for all roads subject to much motor car traffic. This is a matter that will be discussed in one of the articles of the series now running.—Editors.]

Personals.

Mr. J. D. Arey has been reappointed City Surveyor of Sterling, Ill.

Mr. O. A. Turney has been reappointed City Engineer of Phoenix, Ariz.

Mr. Elmer Folsom has been reappointed City Engineer of Bloomington, Ill.

Mr. Joseph W. Hunter has been reappointed State Highway Commissioner of Pennsylvania.

Mr. Howard R. Pratt, Engineer of Maintenance of Way of the Western Maryland Ry., has been appointed Chief Engineer.

Burr & Ferguson, civil, hydraulic and mining engineers, have opened offices in suite 216-217 Loo building, Hastings and Abbott Sts., Vancouver, B. C.

Prof. B. J. Dalton, instructor in civil engineering at the University of Kansas, Lawrence, Kan., has been appointed Chief Engineer of the Cherryvale, Oklahoma & Texas R. R., a new railroad which will shortly be under construction.

Mr. E. Fischer, formerly Engineer of Bridges and Buildings of the Missouri Pacific Ry., has been appointed Resident Engineer of the St. Louis, Brownsville & Mexico R. R., with headquarters at Brownsville, Tex.

Mr. T. H. Webb, heretofore Assistatnt Engineer of the Wichita Falls & Northwestern Ry., has been appointed Chief Engineer to succeed Mr. R. A. Thompson, who has become Engineer of the Interstate Commerce Commission of Texas.

Mr. Harry A. Young, for some time located at Camaguey, Cuba, where he was engaged in constructing a new water system for Camaguey, has returned to New York City to become engineer with the Jobson-Hooker Constructing Co.

Mr. W. O. Myers has been appointed Secretary and General Superintendent of the water works and electric light plant of Ottawa, Kan., taking office June 1st. Mr. Claude S. Pugh, his assistant for a number of years, succeeds him as City Engineer of Ottawa.

Mr. R. Winthrop Pratt, Chief Engineer of the Ohio State Board of Health, has been appointed Director of Sanitary Engineering to the Cuban Government. Mr. Pratt has been granted a year's leave of absence by the State Board of Health of Ohio, during which Mr. Paul Hansen, at present Assistant Engineer, will become Acting Chief Engineer.

Mr. Francis P. Bergen of Williams & Bergen, San Francisco, Cal., advisory engineers for the Civic League, an organization of the property interests of that city, on the work now in progress of construction and authorized by a recent bond issue of $18,200,000, has been in Chicago the last few days for the purpose of investigating what has been done regarding the proposed high-pressure fire protection system, as well as obtaining other information that will be of benefit to the city of San Francisco. Mr. Bergen will visit many cities in the East, in which the question of better fire protection is being seriously considered, and will return to San Francisco about July 15.

Catalogs Worth Having.

Engineers and contractors should have on file the latest catalogs of machines, tools and supplies that they use. In sending for catalogs reviewed or advertised in this paper, you will confer a favor on us if you will write direct to the advertisers and state that you saw the catalog mentioned in ENGINEERING-CONTRACTING. If you are in the market for tools, machinery or supplies, tell us and we will notify promptly the leading manufacturers.

No. 1264. **Troy Dump Boxes.**—Troy Wagon Works Co., Troy, O.

This handsomely printed 12-page pamphlet illustrates and describes the Troy dump box, which the above named company manufactures for application to any wagon gear. The special features ot the Troy dumping mechanism, for which unusual durability and efficiency are claimed, are described and illustrated.

No. 1265. **Vitrified Pipe vs. Brick Sewers.**—Blackmer & Post Pipe Co., St. Louis, Mo.

This is a well-printed and handsomely illustrated pamphlet arguing the advantages of using large sizes of vitrified pipe in place of brick for sewer construction. The pamphlet gives a number of useful hints for handling and laying large-size vitrified pipe. It should be of interest to city engineers and superintendents of sewers.

No. 1266. **Gasolene Driven Locomotives.**—Milwaukee Locomotive Mfg. Co., Milwaukee, Wis.

The above named company manufactures an extended line of gasoline driven locomotives for use on industrial railways and in contract work. The pamphlet describes the construction of the locomotives in great detail, points out the advantages of the engine used and gives tables of sizes and dimensions. Contractors will be interested in examining the locomotives which are offered for general contract work, tunnel and canal construction.

No. 1267. **Baltimore Sewerage System.**—Blaw Collapsible Steel Centering Co., Westinghouse Bldg., Pittsburg, Pa.

This 16-page pamphlet illustrates by photographic views the use of Blaw collapsible steel centers in constructing the large new sewers for the Baltimore sewerage system. The main outfall sewer of this system is 12 ft. 3 ins. wide and 11 ft. high.

No. 1268. **Machinery and Tools.**—Brown & Sharpe Mfg. Co., Providence, R. I.

This is a general catalog of a full line of machine tools manufactured by the above well known firm. The catalog contains 551 pages and practically every kind of machine tool is illustrated and described in sufficient detail to enable a purchaser to order direct from the catalog.

No. 1269. **Motor Lawn Mower & Roller.**—Austin Mfg. Co., Manhattan Bldg., Chicago, Ill.

The machine described in this catalog is a lawn mower and lawn roller operated by gasoline power. It is interesting to know that this company is prepared to make road rollers operated by gasoline power of all sizes that are commonly used in road and street work.

No. 1270. **Success Winning Machinery.**—Chicago Concrete Machinery Co., 20 South Canal St., Chicago, Ill.

This little pamphlet illustrates and describes briefly the line of concrete mixers and hoists, concrete barrows and carts and stone crushers sold by the above named company.

No. 1271. **Up-to-Date Methods in Steam Logging.**—Lambert Hoisting Engine Co., 117-123 Poinier St., Newark, N. J.

This 52-page pamphlet is a general catalog of the full line of hoisting engines and hoists manufactured by the above well known company. Particular attention is given to illustrating and describing the use of Lambert machinery in logging work. Some of the illustrations are exceedingly interesting in showing to what extent modern hoisting machinery is being used by lumbermen

No. 1272. **Grading Machinery.**—Smith & Sons Mfg. Co., Kansas City, Mo.

This catalog describes and illustrates the line of road and earth work machinery manufactured by the above named company. Particular attention is devoted to the company's wheel and drag scrapers. Among the other machines described are plows, dump wagons, road machines and rock crushing machinery.

No. 1273. **The Kindling Squeegee.**—The Kindling Machinery Co., Milwaukee, Wis.

This 14-page pamphlet describes and illustrates the Kindling street washing machine. This machine consists of a tank from which sprinklers feed water on to a steel cylinder carrying soft rubber fins which revolve when the machine is hauled and so scrub the street with water. The construction of the machine, methods of using it, and results obtained are given in the pamphlet.

No. 1274. **Drag and Wheel Scrapers.**—Harry J. See Co., Deedsville, Ind.

This little pamphlet describes the full line of wheel and drag scrapers, plows, wheelbarrows, etc., manufactured by the above named company.

No. 1275. **Gas Traction Engines.**—Gas Traction Co., Minneapolis, Minn.

This is a handsomely printed catalog of 16 pages describing and illustrating the gas traction engines made by the above named concern. The engine is described in considerable detail and some very interesting records are given of the work which it will perform.

No. 1276. **Oiled Roads.**—Good Roads Improvement Co., Cincinnati, O.

In this pamphlet the above named company has compiled a large amount of information regarding oiled roads taken from the reports of the United States Government experts and from the papers read at the Paris convention on good roads improvement. This pamphlet should be of interest to road engineers and superintendents.

No. 1277. **Road Machinery.**—Acme Road Machinery Co., Frankfort, N. Y.

This is a 12-page catalog of the complete line of road machinery manufactured by the above named company. As most contractors know this company manufactures a very full line of road machinery. The catalog describes the various machines in detail and shows a large number of arrangements of crusher plants suitable for road work contractors.

No. 1278. **Boiler Logic.**—Heine Safety Boiler Co., St. Louis, Mo.

Under the above title the company named gives a very good technical discussion of steam boiler construction and operation.

No. 1279. **Dump Buckets.**—The Union Iron Works, Hoboken, N. J.

This 26-page pamphlet describes the full line of dump buckets, tubs, dump cars, barrows and carts and cableway skips made by the above named firm. Tables of dimensions, capacity and prices are given.

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The Proposed Lakes to the Gulf Deep Waterway.

A sum of [illegible] for construction and another sum of [illegible] annually for maintenance will provide a 14 ft waterway from Chicago to the Gulf of Mexico. These are the figures [illegible] [illegible] under Congressional [illegible]. The [illegible] of the [illegible] Congress [illegible] June 8 and [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] its [illegible]. [illegible] the report [illegible] 14 ft channel [illegible] [illegible] [illegible] [illegible] [illegible] the construction [illegible] [illegible] [illegible] [illegible] [illegible] the deep waterway [illegible] [illegible] [illegible] the [illegible] [illegible] [illegible] [illegible] [illegible] a brief review of the [illegible] work [illegible] pertinent and this we hope to present in an early issue.

The idea of a lakes to the Gulf waterway is very old. The first important canal was the Illinois & Michigan Canal which was opened for traffic in 1848 from Bridgeport on the Chicago River to La Salle on the Illinois River, a distance of 97 miles. Subsequently work was carried on improving the Illinois River below La Salle, the idea being to provide a navigable channel 7 ft deep with locks and dams. Both the State of Illinois and the Federal Government contributed to this river work. Then the Chicago Drainage Canal project came along and was begun primarily for sanitary purposes, but secondarily with the idea of making it a link in a deep waterway to the Gulf. The project for a 7 ft improvement of the Illinois River was abandoned and the interests promoting it declared themselves for a 14 ft waterway from Lockport, the terminus of the Drainage Canal to La Salle to be built by the United States. Meanwhile the Drainage Canal was completed to form a waterway 22 ft deep and 36 miles long from Lake Michigan.

In 1902, as the result of the agitation for the 14 ft channel Congress provided for a board of engineers to prepare plans and estimates of cost for a 14 ft channel from Lockport to Grafton on the Mississippi River. At the same time it called upon the Mississippi River Commission to [illegible] [illegible] for a 14 ft channel from Grafton to St. Louis. These bodies reported results in 1905. The report proposed [illegible] [illegible] from Lockport to [illegible] [illegible] [illegible] [illegible] [illegible] Grafton [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] The [illegible] of the work from Lockport to Grafton was [illegible]. The [illegible] Mississippi River Commission for the [illegible] from Grafton to St. Louis was to [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] St. Louis [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] the [illegible] [illegible] 14 ft of water in the canal. The cost of this [illegible] [illegible] [illegible] [illegible]. This [illegible] added to the cost of the work from Lockport to Grafton made a total cost of [illegible] for [illegible] miles of 14 ft channel.

The report of the board of engineers [illegible] [illegible] [illegible] Congress [illegible] [illegible] St. Louis [illegible] [illegible] of the Mississippi. Before considering it however it should be noted that the State of Illinois through its Internal Improvement Commission has taken steps to construct as a state enterprise a 14 ft channel from Lockport to Utica [illegible]. The general plans for this work were outlined and discussed in our issues of Oct. 14 and Nov. 13, 1908, and June 9, 1909. Briefly the present status of the project is this. The people of Illinois at the November election of 1908 voted an amendment to the constitution authorizing the State to issue bonds to the amount of $20,000,000 for construction. At the session of the State Legislature just adjourned a bill was presented providing for this bond issue and for an organization to carry on the work, but this bill failed of passage.

Returning now to the army engineers' report submitted to Congress on June [illegible] [illegible] plans were [illegible] [illegible] [illegible] [illegible] storage reservoirs was reported as impracticable. Any of the other [illegible] plans [illegible] [illegible] [illegible] canalization with movable [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] combination of methods were practicable [illegible] [illegible] [illegible]. Of these [illegible] [illegible] [illegible] [illegible] [illegible] "combination of methods." It provides [illegible] [illegible] [illegible] [illegible] [illegible] St. Louis and Cairo [illegible] [illegible] [illegible] [illegible] Below Cairo [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]. The cost of the work is divided as follows:

Completing [illegible] [illegible] from

St. Louis to Cairo	$[illegible]
Dredging, Deep Cairo	[illegible]
Construction [illegible] below Cairo	[illegible]
[illegible] [illegible] work below Cairo	[illegible]
[illegible] [illegible] Cairo	[illegible]
Total	$[illegible]
Total [illegible] [illegible] charge	[illegible]

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This total of $128,000,000 added to the $30,000,000 cost of the work from Lockport to St. Louis makes the grand total of $158,000,000 for construction first mentioned.

Specifically the studies briefly mentioned above for a 14-ft. Lakes to Gulf waterway seem to have demonstrated that such a waterway is entirely feasible from an engineering point of view and that its cost for construction alone will be less than $160,000,000. Incidentally we have the opinion of the army engineers reviewing the plans that available commerce does not warrant the expenditure, an opinion which, many persons including engineers vigorously dispute.

The Work of the Annual Convention of the American Water-Works Association.

The 29th Annual Convention of the American Water Works Association in Milwaukee last week was well attended and the waterworks world has now added to its best printed matter another volume of valuable papers on the construction and operation of American water works and the relation of public utility corporations to the public they serve. The list of papers printed in another column shows the extent of the work taken up and considered by the members and discussed in a live manner by those present. It is an unusually broad program and was well carried out.

It is noticeable that practically only one paper dealt with construction work, whereas in former years this was a prominent subject. Where much detail was gone into it was along the line of every day operation. In the discussions it was plain that the interest of the members lay least with construction and operation, but was strong on questions of public interests as affecting or as affected by the service rendered the public by public utility corporations. That is, the larger matters of management are at present causing most trouble to the water works companies owned privately.

It happens queerly enough that while the larger questions of management overshadow at the conventions the lesser papers on constructions and operation, in the discussions the most important fact brought out was that an intimate knowledge of methods and costs is required when the public comes in. The papers calling out the most lively discussion were those on the Wisconsin Utility Law and the masterly paper modestly entitled "Notes on Going Value and Methods for Its Computation," by Mr. Alvord. One sentence taken from Mr. Alvord's paper illustrates this point:

> "Competent and experienced appraisers familiar with the art of constructing and operating water plants, and having wide experience with varying conditions, have usually agreed within quite reasonable limits in computing value."

So that even though the discussions may be most lively over the larger questions of policy and management, yet the knowledge of methods and costs so essential in the man who has charge of large works is, after all, the determining factor when questions of adjustment of interests arise.

Common business ability is sufficient to serve the manager, for common business ability presupposes executive ability and the man who possesses executive ability of the right order is the man who never "butts in." Given a manager of good executive ability and the most cursory knowledge of water works operation there will be smooth sailing until the people served consider that some degree of interest manifested by them might redound to their benefit—this benfit to result in lowered charges for service, better fire protection, or municipal ownership or control. The two latter, of course, are to the average citizen something that means lessened cost for service. At this time the manager absolutely requires a man to help him who is familiar with the art of construction and operation and having wide experience with varying conditions.

Today there is one way to acquire this wide experience that former generations of engineering did not have. The modern engineer must be a reader. To his own experience, which must be necessarily more or less restricted, he can add a knowledge of the experience of others. Within the past few years a new generation of engineers has arisen, one that is not afraid to talk of and write about the little things that concern them. The courts have long recognized that a man who is actively engaged in certain work and is a student of books and papers dealing with that line of work is often better as a witness than a man who tramps his little circle of daily duties oblivious to the experience of all men. The American Association of Water Works has been one of the great improvement factors in water works construction and management in this country. The members today show that the modern engineer is developing and can come from the engine room and boiler room and pump house and can climb out of the trench and doffing overalls come out as a man well qualified to discuss the broader subjects affecting the interests of the people. Yet, withal, if he does his part in the world he cannot always discuss the larger questions, but must be a man dilligent in his work and a master of the details pertaining to it. The convention is his recreation from which he comes back inspired to do better work after a little rest from his labors and some heartsease communion with his fellow workers in distant places. Incidentally such conventions, as was particularly the case at Milwaukee, affords opportunity through the study of manufacturers' exhibits to keep posted on late development in waterworks appliances.

Program of the Annual Convention of the American Water-Works Association at Milwaukee.

A program of 32 papers was presented and discussed at the annual convention held at Milwaukee, June 7-12, 1909, by the American Water-Works Association. In succeeding issues we shall present digests of a few of the more important of these papers from the points of view of the construction and coil data engineers. The titles of the papers presented and the names of their authors are as follows:

Some Suggestions Relating to Uniformity in the Accounts, Financial Reports and Statistics of Water Works, by Albert H. Wehr.

The Valuation of Water Power and the Estimation of Steam Diversion Damages, by Robert E. Horton.

The Sanitary Condition of the Southern End of Lake Michigan, by J. Herbert Brewster.

High Duty Pumping Records at North Point Pumping Station, Milwaukee, Wis., by Cornelius T. Myers.

Modern Boiler Practice, by John W. Hill.

Municipal Ownership in Edmonton, by A. Maclean.

Liability of Water Companies for Fire Losses, by Chester R. McFarland.

Some Results Obtained by the Application of Hypochlorite of Lime on Mechanical and Slow Sand Filters and the Method of Controlling Coagulent and the Operation of the Orifice Boxes, by A. E. Walden.

Water Softening or Purification and its Saving, by M. Miller.

Coals for Hand-fired Steam Plants, by D. T. Randall.

Wisconsin Public Utility Law: Its Operation and Results, by Charles B. Salmon.

Meters and Meter Rates, by W. Volhardt.

Boiler Equipment, Practice and Results at Pumping Station, Water Department, Harrisburg, Pa., by George G. Kennedy.

Boiler-room Symposium, by Jay M. Witham, Philadelphia.

The Boiler Water, by Edward Bartow.

Superheating for Duty, by E. H. Foster.

The Sterilization Plant of the Jersey City Water Supply Company at Boonton, N. J., by J. L. Leal, A. M., M. D.

Description of the Process and Plant of the Jersey City Water Supply Company for the Sterilization of the Water of the Boonton Reservoir, by George W. Fuller.

Description of Methods of Operation of the Sterilization Plant of the Jersey City Water Supply Company at Boonton, N. J., and Discussion of Results of Analysis of Raw and Treated Water, with Notes on the Cost of the Treatment, by George A. Johnson.

Concrete in Water Works Construction, by William Curtiss Mabee.

Cheap Transportation and Delivery of Public Water Supply, by H. C. Heermans.

Useful Uniform Accounts and Reports of Water-Supply Systems, by L. G. Powers.

Tests of Modern High Duty Pumping Engines (Crank and Fly-Wheel Type) with and without Superheated Steam, by John Primrose.

Acquisition by New York City of the Larger Two Water Systems of Staten Island, by Louis L. Tribus, M. Am. Soc. C. E.

Water Supply and Treatment for Power Plant Purposes, by William Miller Booth.

The Purchase of Coal upon a Heat Value Contract, by Edward H. Taylor.

Concrete and Reinforced Concrete Section

Note:—This section is devoted to methods and cost of constructing concrete and reinforced concrete structures. It will cover the selection, testing and proportioning of concrete materials; laboratory tests of concrete; concrete mixing, transportation and placing; fabrication and placing of reinforcement, and form construction and erection. It will also contain articles on new and interesting developments in the design of reinforced concrete.

Method of Constructing Concrete Abutments on Concrete Cylinders for a Skew Bridge Across the North Shore Channel of the Sanitary District of Chicago.

There are 23 bridges to be built in constructing the North Shore channel of the Sanitary District of Chicago. Three of these bridges are to be railway bridges and the substructure of one of these bridges, the one carrying the tracks of the Mayfair cut-off of the Chicago & Northwestern Ry., over the channel, is the subject of this article. This substructure is unusual in several particulars. The long abutments made necessary by the skew crossing of the channel and railroad tracks are supported on concrete cylinders sunk to bed rock and reinforced; from the front toe of each abutment a vertical concrete apron wall extends down to a level well below the bottom of the channel. These apron walls are braced apart by concrete struts extending across the channel flush with its bottom. These details will be referred to more particularly further on.

The bridge will be a [illegible] girder with ballasted floor constructed to carry three railway tracks across the channel at an acute angle. It will consist of parallel plate girders extending transversely across the channel at right angles with I-beams between the girders. The clear way under the bridge between bottom of girders and normal hydraulic grade line of the water surface in the channel is [illegible] ft. This necessitates elevating the present railway tracks some 7½ ft. at the bridge. This elevation, with the inclined approaches on 0.1 per cent grades and with the diversion of the tracks around the bridge (see Fig. 1) during construction, is being done by the railway company. The contract for the bridgework proper, including excavation, [illegible], Chicago, Ill., at the following contract prices:

[illegible] excavation, per cu. yd. [illegible]
[illegible] excavation, per cu. yd. [illegible]
Concrete No. 1, per cu. yd. [illegible]
Concrete No. 2, per cu. yd. [illegible]
Concrete cylinders, per cu. ft. [illegible]
Steel linings, per lb. [illegible]
Reinforcing steel, per lb. [illegible]

Specified Materials.—Portland cement is required to meet the specifications of the American Society for Testing Materials. Sand is required to be clean, sharp and coarse and to contain no more than [illegible] per cent of loam, earth, [illegible] or other foreign matter. Crushed limestone is to be produced from tough, hard stone and screened free from all particles passing a ½-in. mesh [illegible]. [illegible] is required to [illegible] ½-in. [illegible]. Reinforcing steel is required to be either corrugated or twisted bars rolled from [illegible] open-hearth steel [illegible] in accordance with [illegible] Standard Specifications. No. 1 concrete [illegible] No. 2 concrete [illegible] mortar [illegible] Mortar [illegible] for bedding and [illegible] 1:3 mixture for pointing. [illegible] the Standard Asphalt & Rubber Co., of Chicago, Ill., or [illegible] equal.

Generally No. 1 concrete is used in the [illegible]

[illegible]

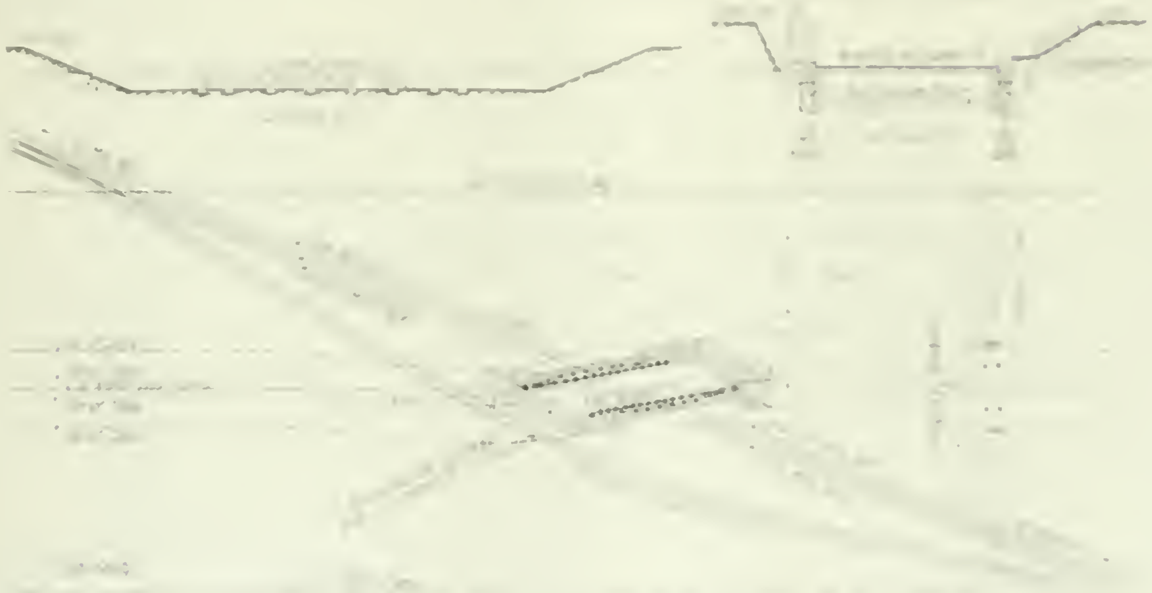

Fig. 1. Plan of Crossing of North Shore Channel and Chicago & Northwestern Ry.

at considerable depths hardpan or ledge rock, which are essentially the conditions in Chicago where concrete cylinder foundations have proved economical and successful.

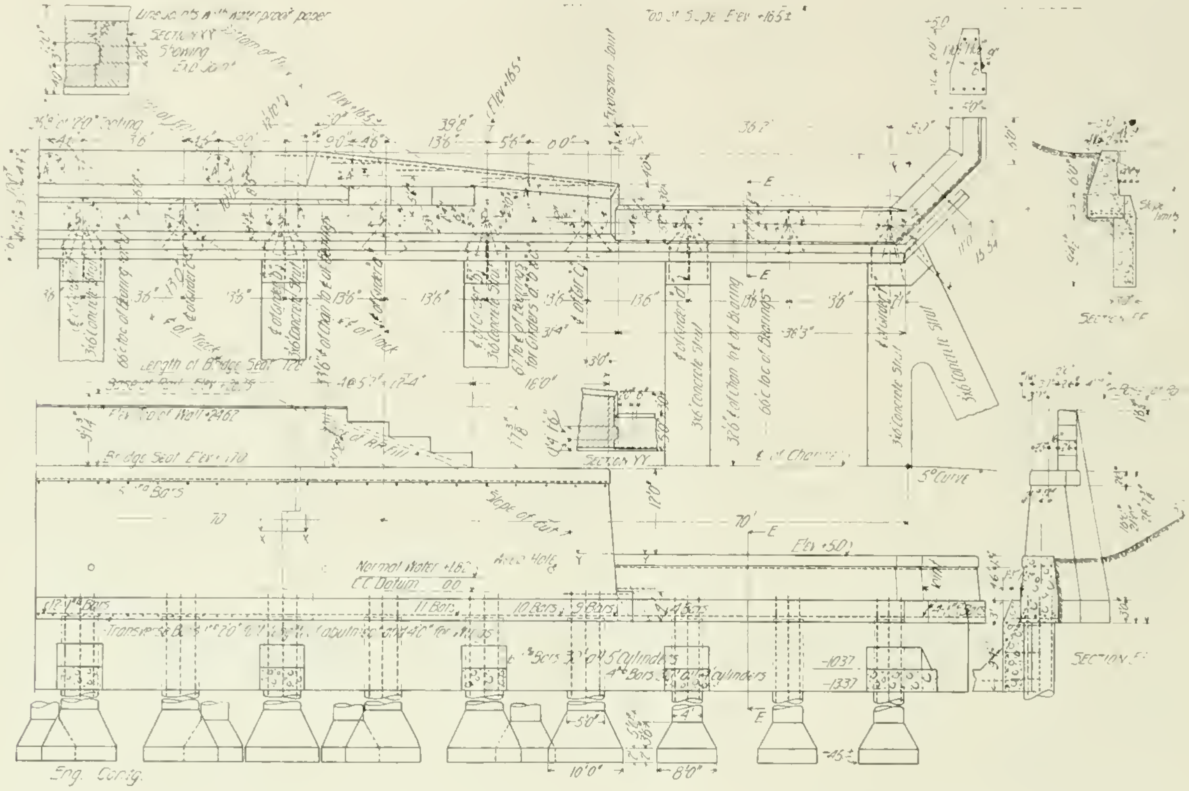

Fig. 2. Details of Concrete Abutments for Chicago & Northwestern Ry. Bridge Across North Shore Channel.

The cylinders were built by excavating a circular pit by hand and curbing it with wooden staves as it deepened. A timber horse, carrying a hand windlass as shown by Fig. 3, was set over each pit to hoist out the excavated material in metal tubs. The lagging used consists of yellow pine staves 5 ft. long of 2x6-in. lumber surfaced on the inside, with edges cut radially and tongued and grooved. Therefore the excavation proceeded to a depth of 5 ft., when a ring of lagging was placed, and so on repeatedly. To hold the lagging in place against the pit walls inside steel strap hoops or rings were used. For the 4-ft. cylinders the section of the ring was 2½x½ ins., and for the 5-ft. cylinders it was 3x⅝ ins. Two rings were used for each 5-ft. section of lagging and each ring was made in two pieces with ends bent in to form lugs for bolting. In excavating, 1 man worked in the pit, 2 men at the windlass and 1 man clearing away the dumped soil. The arrangement of horses, platform, etc., is clearly shown by Fig. 3. Figure 4 is another view of the work showing the soil from the pits and the Paige power drag scraper excavator which is making the general excavations for the foundation.

For filling the cylinders or wells No. 1 concrete was used. This was mixed wet enough to flow readily around the reinforcing metal and close against the lagging. The mixing was done in a batch mixer made by the Chain Belt Co., of Milwaukee, Wis. As shown by Figs. 3 and 4 the mixer was located on the bank above the cylinder pits and discharged directly into a chute leading into the pit tops. The stock piles were on the bank adjacent to the mixer and stone and sand were wheeled from piles to mixer. The mixer was equipped with the Standard Chain Belt elevating charging hopper which when lowered received the barrow loads from ground level and made inclines and staging unnecessary. The elevating charging hopper held a full batch of materials and charged the mixer in full batch units.

The constructing of each cylinder was made a continuous process. When this continuity had to be interrupted special methods were adopted, as follows: If the concrete had only partially set before resumption of work, the first 2 ft. depth of new concrete was lowered in buckets and carefully spread; if the old concrete had set hard the top surface was bush hammered and cleaned and a layer of mortar was spread on it before adding fresh concrete. Ordinarily the concrete was deposited by a free fall from the mouth of the chute at the top of the cylinder pit.

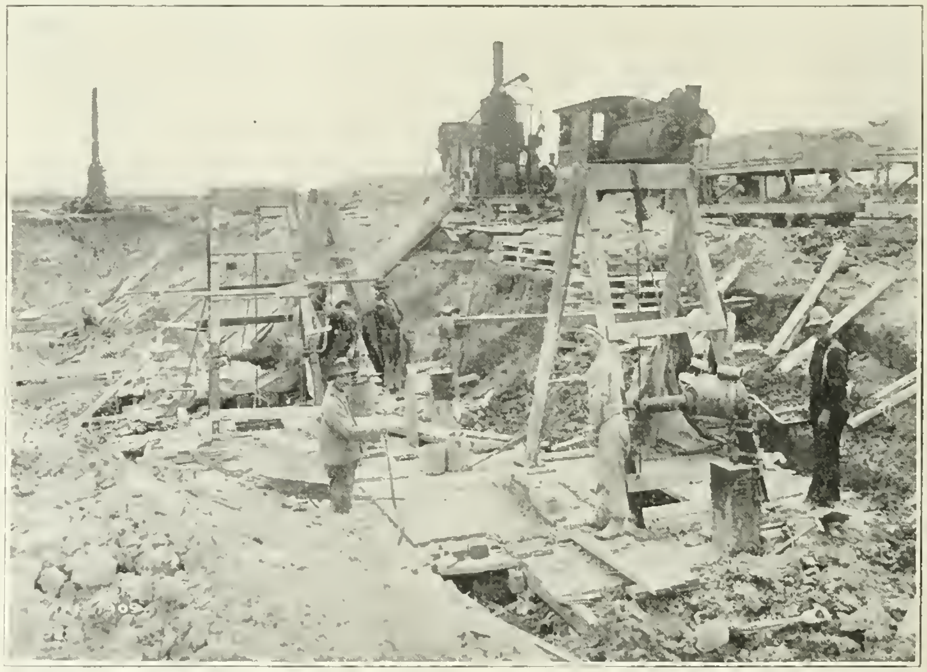

Fig. 3. View Showing Method of Digging Wells and Concreting Cylinders.

As stated above, the contract price for concrete in cylinders was 52 cts. per cu. ft. or $14.04 per cu. yd. This price included excavation, curbing and all materials, labor, plant and tool charges, etc., incurred in the cylinder construction except the reinforcement, which was contracted for at a separate price of 2½ cts. per lb. For a further description of cylinder foundation construction of this type as applied to building work in Chicago, together with costs, the reader is referred to Engineering-Contracting for Nov. 21, 1906.

Methods of Abutment Construction.—At this time work has not been begun on the abutment walls or other concrete work than the cylinders. The following remarks, therefore, refer to specified methods. The abutments, certain walls and struts will be constructed of No. 2 concrete, except exposed surfaces and bridge seats, which will be of granite concrete. All this concrete is to be deposited in horizontal layers not exceeding 10 ins. in thickness and thoroughly tamped. The usual requirements for keeping horizontal lines, for bonding new concrete to old and for finishing will be followed. In respect to concreting reinforcement the specifications say: "All horizontal bars shall be surrounded with mortar of the quality used in concrete, sufficient in amounts to thoroughly cover all surfaces of the bars and insure perfect contact therewith." The form work required corresponds to usual good practice. The following suggestions for tieing forms are given:

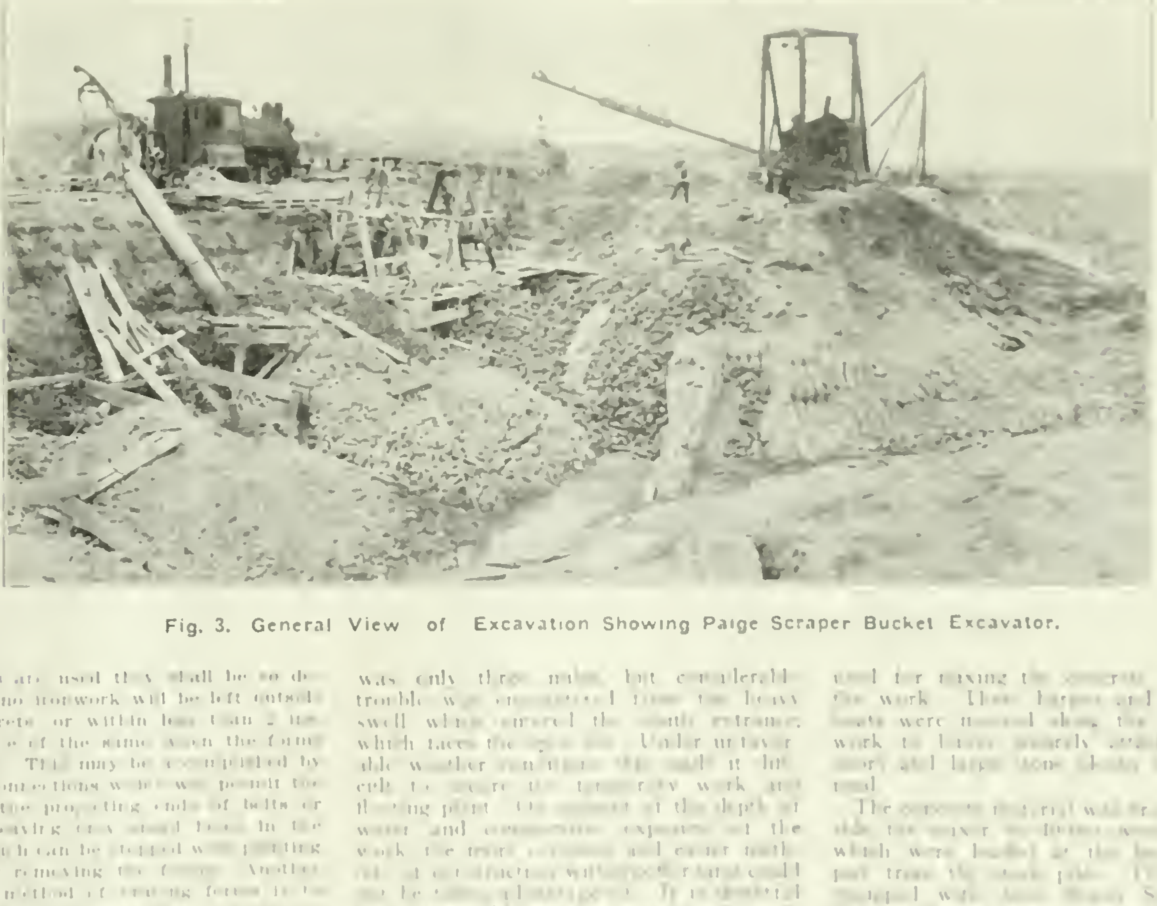

Fig. 3. General View of Excavation Showing Paige Scraper Bucket Excavator.

If tie rods are used they shall be so designed that no ironwork will be left outside of the concrete or within less than 2 ins. from the face of the same when the forms are removed. This may be accomplished by sleeve nut connections which will permit the removal of the projecting ends of bolts or rods, etc., leaving only small holes in the concrete which can be stopped with pointing mortar after removing the forms. Another satisfactory method of treating forms is to construct them with cross ties between the front and back, these ties to be placed at frequent intervals along the lower portion of the form, and to be removed as the concrete is built up, the upper set of cross ties on which the forms are constructed being sufficiently long to extend above the top of the finished masonry, and at least one set of these being used above this level.

For the information from which this description has been prepared we are indebted to the contractors, J. T. [illegible] & Co., Chicago, Ill., and particularly to the engineers of the Sanitary District of Chicago: G. M. Wisner, M. Am. Soc. C. E., Chief Engineer; L. K. Sherman, Assistant Engineer, and C. K. Dart, Bridge Engineer.

Method of Constructing a Concrete Mass and Blockwork Quay Wall at Portland Harbor, England, With General Costs and Some Comments on Concrete Work in Sea Water.*

BY [illegible]

The quay wall, which is described in this paper, was built at Portland Harbor, England, in the years 1904-1905. The wall is built of Portland cement concrete masonwork faced with concrete blocks. The foundation of the wall up to 33½ ft. below low water level of spring tides is built of mass concrete. Above this point the wall is faced with 8-ton blocks backed with mass work to the level of 2½ ft. above low water level. From this level to quay level the wall is finished of mass concrete faced with a 12-in. layer of granolithic concrete. A coping of dressed Devonshire granite completes the wall.

This work was constructed within the comparatively sheltered area of the harbor. The longest water reach inside the harbor tending to [illegible] the work was only three miles, but considerable trouble was encountered from the heavy swell which entered the south entrance, which faces the open sea. Under unfavorable weather conditions this made it difficult to secure the temporary work and floating plant. On account of the depth of water and consequent expense of the work, the usual cofferdam and caisson methods of construction with temporary staging could not be economically employed. It is doubtful if a dam could have been made sufficiently strong to keep watertight and withstand the swell and the probable damage from floating plant and vessels [illegible] a [illegible] port.

It was therefore decided to build the work entirely in open water by the aid of helmet divers. The first work undertaken was of course the dredging of the foundation trench and the [illegible] of the earth in front of the wall. This work was done by the ladder dredger "Cornwall," a vessel owned by the contractors, and built to dredge 50 ft. below her still load line.

The foundation was dredged until the hard shale and a satisfactory formation was reached, borings having been taken which established the presence of shale rock at a considerable depth below the earth line.

The trench was dredged with slopes of the bank and front of the wall to permit room for work in and allow for the mud sliding down the bank and filling up the trench at the bottom of the trench before concreting could commence. However, very little trouble was experienced from sliding, the small amount which did find its way into the trench being easily removed by a grab immediately before the laying of the foundation concrete.

The water at this point, though considerably agitated on the surface and for a few feet down, was practically motionless 30 ft. down, there being practically no currents of any kind to move the mud. The bottom of the foundation trench left by the dredger was found to be remarkably level, requiring no leveling by the divers before commencing on the concreting.

Two 120-ton steel hopper barges, fitted up with a ½-cu. yd. Koppel concrete mixer and a 5-ton Booth steam crane on each, were used for mixing the concrete in situ for the work. These barges and the diving boats were moored along the line of the work to [illegible] in the [illegible].

The concrete material was brought alongside the mixer by [illegible] barges, which were loaded at the harbor works pier from the stock piles. This pier was equipped with [illegible] and [illegible] tipping stages for loading and unloading material. Several [illegible] of construction material for this and other work were handled in this way.

The concrete shuttering for the quay was made in 30 ft. × 4 ft. panels of 2-in. planking, internally braced with 3×12-in. [illegible] consisting of [illegible] attached to the bottom of the panels on the outside at sufficient spacing to hold them in position. The panels were stored on a barge alongside the mixer and handled by the mixer crane. They were set up in the foundation in parallel lines back and front of the wall and secured on the outside with heavy rails and timbers. Small [illegible] were [illegible] by hand to the corners of each section to guide the craneman in depositing the concrete.

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*A paper read before the Canadian Society of Civil Engineers, April [illegible], 1909.

In order to set out the line of the work a barge was securely moored over the work, so as to practically eliminate movement, and the line was given by a transit from fixed points on shore. A 30-lb. plumbbob, suspended by thin piano wire, was used to continue the line from the point on the barge down to the diver. This method proved to be quite satisfactory in ordinary weather. Afterwards, when the gantry was erected, line was given from the overhanging boom of the blocksetting cranes.

In the lower part of the work the divers experienced some difficulty from the partial darkness in the foundation trench and the cement particles floating in the water which obstructed the light. Electric lights under water were tried to overcome this difficulty, but were not very successful, and were abandoned by the divers when they had accustomed themselves to the layout of the work. When a 100-ft. length of the bottom 4 ft. layer had been put in, the shuttering was stripped, the trench filled in with stone to the level of the top of the concrete, and the shuttering reset for another layer.

As soon as the blockwork level was reached, the concrete was levelled off to receive the blocks and careful line and level given from the gantry, which was erected as soon as the trench behind the wall had been filled up.

A light section steel rail was used by the diver to level off the concrete for the blocks. The temporary block-setting crane, to be described later, was then erected, and a length of the first row of blocks set and backed up with mass-concrete. Wrought iron skips, containing 1 cu. yd. of concrete, the bottoms of which opened automatically, were used to deposit the concrete.

The same class of shuttering was used for the back of the wall under water as for the foundation work, but slightly modified to enable it to be attached to the crane gantry piles for support. The method employed was simple and satisfactory, and is shown on the drawing.

The blocks were laid with dry joints, Flemish bond, and bonded in addition with 12-in. diameter concrete-in-bag joggles. The top of the masswork backing was leveled off sufficiently wide to take the next course of blocks. The blocks were easily handled by the divers, the cranes working smoothly by means of an arranged code of signals.

A force of 12 divers was kept going, the foreman diver and an assistant setting the blocks, and the others setting and stripping shuttering and erecting the gantry, the two mixers following up with the mass-concrete. The divers were housed in boats, with plenty of room in them for small stores.

Much expense was saved in the purchase of new diving suits by the employment of a skilled repairer. Many divers insist on throwing away, as unsafe, dresses which have become frayed and leaky. This soon happens to the exposed parts of the dress on work where blocks and timber have to be pushed around, and this renewal, on a work of any magnitude, adds considerably to the labor cost. Rubber and jute canvas patches can easily be put on the dresses with repairing solution. A good plan is to cover the more exposed parts of a new dress with protecting patches of this material, and renew them, before the dress itself is attacked. Detachable guards are sometimes used, but are troublesome to the wearer, as the addition of any unnecessary equipment outside of the ballast, piping and signal lines, hinder free movement, and, of course reduces the working efficiency of the diver and adds to the cost of the work.

In work which is difficult of access the fewer lines a diver has to look after the better. The more common accident happens through a diver getting his equipment mixed up and being unable to extricate himself. Each diver should have an intelligent attendant who can see ahead and get the materials, tools, etc., on the spot at the right moment, and so avoid delays and the necessity of the diver's ascent to give verbal instructions. Much of the often abnormally high cost of diver construction is caused by the lack of system. A portable telephone is a very useful adjunct, but is a convenience more than a necessity to the work.

The concrete in the wall varied in its proportion to suit the position and exposure in the work, from that of 1 part Portland cement to 5 parts of aggregate in the foundation and masswork behind the blockwork, to 1 to 6 in the blocks and above-water work.

Stone broken in the works quarries by a crusher plant, sand brought by rail, and sea sand and shingle from the Isle of Wight were used. The average cost per cubic yard of concrete in the wall was about $5.00 for materials and labor. The average output of the mixers was 80 cu. yds. each per day, but their output was limited by difficulties inseparable from diver work. The cost of the wall was approximately $500 per foot run contract price.

For the purpose of comparison with American work, the following labor and material costs are given. They are much lower than on this side, owing to the different standard and cost of living:

Diver, 50 cts. per hour.
Divers' crew, 3 men, 10 cts. per hour.
Carpenters, 16 cts. per hour.
Crane and mixer drivers, 14 cts. per hour
Ordinary labor, 10 cts. per hour.
Cement, $7.65 per ton, delivered.
Mixed sea sand and shingle, 84 cts. per cubic yard.
Sand, $1.50 per cubic yard.
Broken stone, 65 cts. (exclusive of plant) per cubic yard.
Granite chippings, $1.20 per ton of 22 ft. delivered.
Timber for shuttering, $20 per thousand.

The shuttering was repaired and re-used as often as possible. The costs for shuttering was about 12 cts. per sq. ft. of underwater wall surface, and about 9 cts. per sq. ft. for above-water work. This latter may seem high when diver and carpenter costs are compared, but is due to the smaller section of the wall above water.

When the last exposed course of blocks was set, they were carefully aligned, any error being adjusted. A complete 120 ft. length of shuttering for the work above block level was made in 20 ft. x 4 ft. movable panels, double braced in front, and made in panels to suit the counterforts in the wall behind, all held together by 1-in. diameter bolts and braced with removable struts of 4x2-in. stuff inside. Coach screws from the outside were used to secure the lagging to avoid bolt heads in the wall face of the shuttering.

The shuttering for the first layer above blocklevel was placed in position on the ebb tide and at once concreted up. The existence of the counterforts provided assistance in studying the shuttering and preventing movement. The shuttering was then placed in position to quay level and foundation bolts, etc., set in position and concreted up.

It will be noted from the drawing that the shuttering for the back of the wall below the water line was attached to the crane gantry uprights. It was not possible to do this for the upper exposed work, as the gantry, although very steady for a temporary structure, vibrated sufficiently to have injured the alignment of the wall where it showed above the water line, although this movement was of no account lower down behind the wall.

The upper course of blocks, coming as it did well clear of the low water line, enabled the most difficult part of such work, namely, that around the low water line, to be done easily on the ebb, the 2 ft. or so of a fall and rise of the water below the block line giving sufficient time to concrete up ahead of the incoming tide. Care was taken to make the shutters as nearly watertight as possible at this part to prevent the sea from sucking out the green concrete and pitting the face of the wall.

The lower layer of shutters was weighted down with rails to prevent flotation when the concrete was still new, and no trouble at all was experienced from movement of this part of the shuttering.

The lagging for the shutters was of pine, special care being taken to carefully plane and align the exposed face. The whole surface of the shuttering was well rubbed with a coating of soft soap to prevent adhesion of the concrete. The tie bolts were well oiled, and were slightly drifted after the concrete had partially set to loosen them from the concrete and facilitate their removal. By this means they were removed and re-used without injury to the wall.

The concreting progressed continuously with but few delays, the lower panels being removed after three days, reset on a new length, and replaned where any slight warping of the face had taken place. A very good surface was thus obtained. Unfortunately for the use of wood lagging, the warping takes place shortly after the concrete is placed in position, and while it is yet green enough to take the impression of the swollen joints. A thin covering of steel plate on the face of the lagging, the joints of which should be left slightly open to provide for swelling of the timber, overcomes this trouble where a perfect concrete surface is a desideratum without resorting to plastering or acid treatment. All-steel shutters are not sufficiently resilient for sea work; lacking resilience they have to be made unreasonably heavy and costly to resist the rough handling they have to undergo.

The writer has seen massive shutters used in breakwater construction, braced with steel T's, irreparably twisted out of recognition, whereas all timber shutters, though perhaps badly damaged, could, at least, be repaired and re-used.

The exposed facing of this wall, consisting of 1 part cement and 3 parts granit clippings, was deposited simultaneously with the backing to form a homogenious mass, the facing during placing being kept separate from the poorer quality concrete behind by a 6-ft. x 1-ft. steel plate, with handles on one edge, and held the necessary distance from the face of the wall by thin plates rivetted on the face. One man moved this plate up as the work progressed, and deposited and carefully rammed the facing material, and the result, with careful shutter repairs, and the liberal use of the soft soap, was very satisfactory.

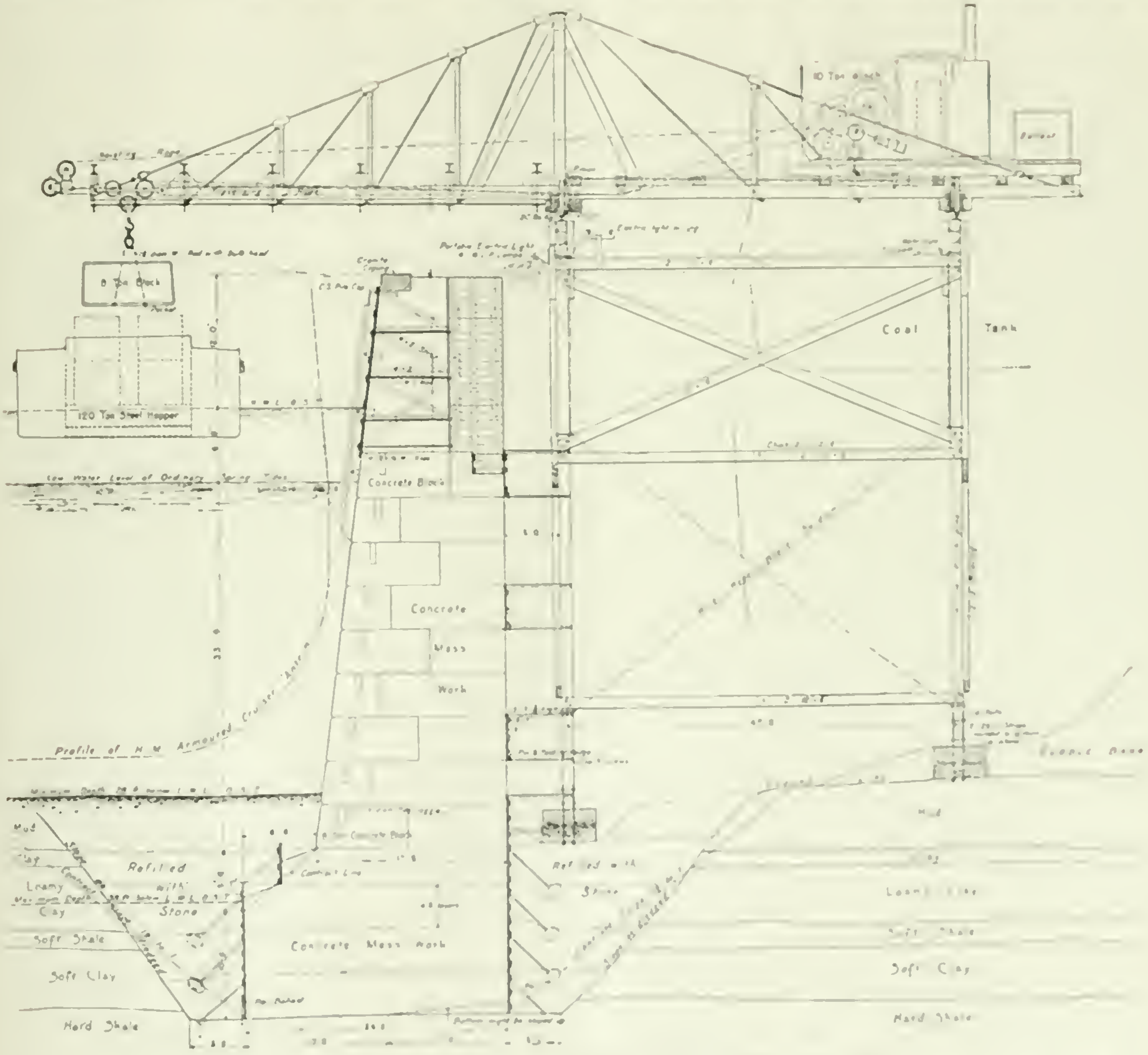
The small ratio of width to total height is a feature in this wall, particularly noticeable at the lower block line, and also the great height of the vertical back of the wall, totaling 68 ft., differing from the usual conception of a non-reinforced quay wall in British practice, in that the usual series of offsets or steps are omitted.

This was made possible by the high angles of repose of the material forming the backing of the wall. This backing is of large rubble, with the interstices filled with smaller spalls, and would stand with but slight support to within a few degrees of vertical. Making allowance for quay loading and strain from moorings it is [illegible] lighter in section than usual, the design being doubtless influenced by the quality of the backing. The writer has seen walls of similar general design notably at Liverpool, Bristol, and Leith, with twice the ratio of width of foundation to height that is used in this wall, but the backing employed was of softer dredged or other material, which though not necessarily the stability of the wall.

With the high angle of repose of the backing the resultant of the overturning moments of the wall comes well within the middle third of the foundation, which, this being the usually accepted rule for a plain retaining wall without any intermediate exterior strain, such as a quay wall is subjected to. The accurate design of this class of work for various places and conditions is much hampered by the lack of designing data other than walls actually built which have stood successfully. No doubt many walls are made needlessly heavy simply for the reason that the average British engineer has a [illegible] and

In this wall the cement used was of the finest quality, and of high proportion in the concrete, and the aggregate clean and sharp and carefully proportioned. The different classes of aggregate were tested for voids. Sand in sufficient quantity was added to the stone [illegible] filled up the interstices and cement added to the proper quality of concrete, or just a little in excess of the quantity required to bind the sand particles. Every ounce of cement added in a concrete beyond the requirement of proper proportions is a waste in strength.

Concrete used in Britain [illegible] that used in this [illegible]



Plan of Gantry Crane and Forms for Concrete Quay Wall.

flattens down to a comparatively small angle with the horizontal on exposure to water action.

No signs of weakness whatever have appeared in this wall. Possibly the insertion of a reinforcement placed in the face of the back, and the use of a few old rails placed vertically near the back of the lower half of the wall at the point where the tensile stress is greatest would have increased the [illegible]

[illegible]

[illegible] the action of salt water [illegible]

One precaution should always be taken in designing concrete work [illegible] up unnecessarily. Of course a small percentage of cement was unavoidably lost, but with careful manipulation of the depositing skips the amount was negligible. After each layer had set, and before another was deposited on top of it, the whole surface was brushed and cleaned. From 2 to 3 ins. of slime, precipitated by the action of the cement on the sea water, always accumulated on the wall under water after concreting. Failure to remove this deposit on the concrete in sea water has been the fruitful cause of wall failures. The cement particles in green concrete coming into contact with the sea water produce a chemical change in the cement and precipitates magnesia from the water.

This process takes place most easily before the concrete has set, and to a lesser degree after it has set. In sea water concrete which has not set should, therefore, be protected until the cement has had time to crystallize and set, and the part of a wall where work has been left off under water and another layer has to be placed later, should be thoroughly scrubbed with wire brushes to remove any particles of the cement which have been damaged by contact with the sea water in an unset state. The particles in most hydraulic cements develop a certain amount of heat during the process of hydration, and tend to rise like an effervescence from the surface of the wall. It can be readily understood that the process of depositing and levelling concrete in the water aggravates the deposit of this precipitate. Possibly the fact that the geological formation of this particular district is of limestone and chalk, and consequent impregnation of the sea water may account for the unusually large amount of the precipitate in this particular case. The writer simply states the case as he personally observed it. The writer dried and tested this slime and found it to have absolutely no setting properties whatever, simply drying up into a fine powder when mixed into testing blocks, so that its introduction in the wall in layers would have prevented bond and made a horizontal joint of non-cementing material, probably half an inch thick when compressed right through the wall at every four-foot layer, which would have caused lateral weakness in the wall. Although this is a gravity wall, and is calculated to have sufficient deadweight to resist lateral thrust, nevertheless the introduction of what would have been a series of joints on the tension face of a comparatively thin wall like this would not in view of mooring stresses have been a desirable feature, although dry joints in the blockwork face do not matter, as they are under compression on that side of the wall.

The writer is of opinion that many cases of failure of concrete in the sea are due to a hot cement being used which swells during the process of hydration and setting in the work, producing holes and cracks which remain in the work after hydration is complete. These afterwards fill up with this same precipitate deposited by the salt water action on the cement, which, having no cementing value, rots away the wall, and the latter finally bursts off in large pieces. The writer has examined walls where pieces have broken away in this manner, and has detected the presence of a coating of this slimy material in the cracks. If the wall were perfectly solid the sea water could not find its way in and so cause this material to be deposited. The same occurrence in a milder form is to be seen in the efflorescence, which shows on ordinary concrete buildings in the form of white blotches and streaks of powdery material. A concrete which is not solid, and allows the water to freeze and expand in the cracks, is also undoubtedly the cause of failure of concrete in many cases, in water subject to frost and variations of water level.

The use of too much neat cement on the surface of a wall also tends, from the different exposure and ratio of expansion and contraction it bears to the inner concrete where more aggregate is used, to scale off the outer layer and produce hair cracks.

To avoid this particular defect on the face of a wall, the aggregate should be worked out against the shuttering and the wall covered with damp sacking while the concrete is maturing.

One insuperable difficulty in mass concrete in water with variations in level caused by the tide is the difference in the expansion and contraction of the concrete above water and that under the water. Blockwork is not so much affected by this as the joints allow free movement. The constantly alternating water levels and consequent changes in expansion and contraction of the material in the wall is very trying to good work, and soon shows its effect on poor concrete around the water line, and when this is coupled with any of the above-mentioned causes of decay, soon results in total failure.

A breakwater in Scotland, of which the writer has knowledge, having been engaged upon it on extension work, built in the pioneer days of concrete in sea work, presents an appearance which clearly indicates a failure to appreciate the importance of thorough aeration of the cement and removal of the salt water—cement precipitate from the top of the layers as deposited, and has been the immediate cause of numerous and costly repairs. At that period, of course, concrete in sea water was in a more experimental stage, and many, though not all, of the difficulties then encountered, both in the chemical composition and constructural use of cement for sea work, have been overcome. This breakwater shows joints of soft material, presumably this same precipitate, at every place where concreting had been stopped, and innumerable small hair cracks and holes in the body of the wall, filled with the same material. It has also, in parts a spongy appearance, even where it is not exposed to wave action, which indicates a tendency for the cementing material to gradually eat away. This is the case in these earlier works, and age only can prove whether modern works will outlast this trouble, which would seem to be a gradual decomposition induced chemically. Vibration in the concrete, caused by the continual pounding from waves, might cause fatigue and consequent failure of the cementing material in a wall exposed to wave action, and has done so, but could not be the cause with sheltered work.

Perhaps we expect too much of nature when we think that our building materials are too short lived.

The every-day process of weathering and leveling down of rocks and all forms of erosion indicate that it is somewhat vain on the part of any man to hope to produce an everlasting material, a thing which is not found even in nature itself. The only thing we can do is to use those which last the longest and then replace them.

Many failures are traceable to some departure from the strict wording of the cement specifications on the part of the makers or the use of hot or dead cement.

The writer does not propose to wander into the realms of chemical science relating to the compositions of cements suitable for salt water, but from personal experience he would advocate the use of a first-class brand of Portland cement, with rigid and unbending inspection as to its guaranteed chemical constituents, age, tensile strength, fineness of grinding and calcination. Manufacturers, and especially middlemen, are occasionally not averse to rushing in a few carloads of insufficiently calcined and aerated cement, under pressure of output, or to dump a few loads of a dead cement in sufficient quantity to ruin a wall and trust to having it accepted in the rush of the work. Several hundreds of tons of cement, which many users would have accepted without remarks, were very rightly rejected on this work, although the concern supplying the cement was of a highly reputable standing in the trade. All cement should be shipped direct from the factory to the site to insure actual delivery of the proper article ordered, and should be carefully stored on delivery. Attention to these practical details is essential in order to insure good work. Some users accept cement which has been peddled and rejected around the country, and throw it around in sacks on the work in all weathers, and innocently wonder what can be wrong with it when the concrete shows signs of early decay, when their own treatment of it has probably been the cause.

A cement which requires to be aerated before use, or one which is partially hydrated, and so rendered practically valueless as a cement, should be rejected without compromise. Its acceptance tends to encourage general laxness in manufacture and distribution.

A cement which begins to set before the concrete can be deposited and rammed in position, ought to be avoided. Not only do the set particles lose their cementing power when moved during placing in position, but many of these cements, with a high initial setting strength and speed, afterwards deteriorate in strength. An ordinary Portland cement concrete should not set very much under half an hour, giving ample time to deposit it.

At Portland the temperature is never sufficiently low to cause freezing, sufficient to affect concrete exposed to tidal action in sea water, but the writer has seen cases where the alternate wetting and drying of sea walls, and consequent freezing of the concrete around the water line, have caused the concrete to scale and burst off in large pieces, presenting a very unsightly appearance. Breakwaters which are wetted by spray or waves above the water line also sometimes present this appearance when subjected to frost. Probably the introduction of some waterproofing material in the outer facing of a concrete wall would improve matters, but although several compositions are on the market, the writer is not aware of any case where waterproofing of concrete has been tried successfully in sea water, if at all necessary. Proper protection of the face of a quay wall from damage by shipping is very desirable, as it is a difficult and costly operation to repair it effectively.

The stone and sand aggregate in a concrete ought to be clean and sharp. Neither the stone or sand particles should be too uniform in size.

A sand, the grains of which vary in size, makes a more solid concrete, and this also applies to the stone, because the smaller pieces fill up the interstices in the larger. Where no artificial coloring is used, it is necessary to use concrete materials of a uniform color if evenness of finish is desired. Nothing looks worse on a concrete wall than a patchy appearance, caused by using different makes of cement and changing the aggregate.

For the manufacture of the concrete facing blocks of this wall, a blockyard was constructed with a [illegible] gantry traveler running the whole length of the yard.

A large area of [illegible] on which to build the blocks, was placed at one end with two Baxter jaw stone crushers arranged in series and a [illegible] sand [illegible] driven by a 20-HP engine.

The cement storage building was placed at one end next the mixer in a convenient position. The stone to be crushed was brought from the contractor's quarries in cars thrown by hand [illegible] from the cars into the crushers, and thence [illegible] the screened stone into skips running on a narrow gauge road, which were also filled with the cement and sand, up an incline by an endless rope [illegible] by a winch and dumped in the mixer.

The concrete was dropped from the mixer into skips with opening bottoms handled by the gantry crane. The blocks were stripped and stacked along one end of the yard, down which ran car tracks for loading.

Four days were allowed for the blocks to set before the removal of the casing, and they were then numbered and dated and stacked, a few days being [illegible] to mature. The shuttering panels for the blocks were made of 3-in. pine, strongly braced, planed smooth, and well rubbed with soft soap before use. Provision was made for means to stack and set the blocks by leaving openings down the center of the block to take two inclined lewis bolts in such a position as to be easy to withdraw and balance the block in a level position convenient for setting when being handled by the divers. Several of the blocks, which were afterwards used in the mass concrete, were split up to test the proportioning of the aggregate, and found to be perfectly solid. Three months were allowed to elapse before the blocks were permitted to be set in the quay wall.

For the purpose of setting the blocks two gantry cranes were set up in the center of the length of the wall and worked away from each other towards the ends of the wall. A 210-ft. length of gantry framing was erected, and when the blockwork reached the top in the center, the gantry was broken in the middle and removed and extended towards each end. Each part of the gantry was built in a slip on shore and towed to the site, where the foundation blocks of roughly squared stone were attached to the bottom of the vertical piles and the section sunk into position. These blocks were made sufficiently heavy to overcome the buoyancy of the timber, and were left behind on the removal of each section. The foundations for the stone blocks were leveled off with spalls by divers at levels to suit the length of the piles, and the erection was cheaply and quickly done.

A ten-ton crane mounted on a large steel barge was tried for setting a few blocks in a position which the gantry crane could not easily reach, and though the work was accomplished, the [illegible] and heave of the vessel [illegible] the manipulation of the blocks rendered it extremely difficult and even dangerous for the diver to set it. In calm water, with a large barge, blocks of large dimensions can be set successfully by this method, and consequently, more cheaply if suitable floating plant is available for a moderate-sized work, for which the construction of [illegible] plant would not be justified.

The contractors for the whole of the work were Messrs. W. Hill & Co., of Westminster, London, the writer being their chief assistant engineer, with outside charge on the work.

Earth and Rock Section

Note: This Section is devoted to methods and costs of excavating earth and rock and building embankments. It will cover the grading of roads and railroads, diking and canal work, dredging, building reservoirs and earth dams, sewer and water pipe trenching, quarrying, etc.

Comments on Methods of Excavating Trenches and Ditches: Excavating Deep Trenches by Hand, and Unwatering the Trench and Ditch.

(Continued from June 9 issue.)

In excavating trenches by hand should a long handled shovel be used, a man can throw the material onto the bank until the trench becomes about 5 ft. deep, then the amount of work he will do rapidly decreases, and much of the material will roll back into the trench. Some few men are able to throw material from a trench 10 ft. deep, and the writer once had in his employ a man who could do a fair day's work in casting from a trench as much as 15 ft. deep, throwing it [illegible] at least 5 ft. wide, but even if a man [illegible] seldom [illegible] it will, as a rule, [illegible] the limit of economical work. When the trench is to be taken deeper than this the material should be handled in two or more lifts.

Judgment must be exercised in placing platforms, and in deciding on their height. Frequently they are placed in a haphazard manner, and the amount of work done per day is cut down. When sheeting or sheet piles are used in a trench, it is an easy matter to place platforms either on the waling, on the cross braces or on cleats nailed to the sheet piles themselves. In wide trenches [illegible] platforms are placed on the side of the trench and the earth is thrown onto them either from the side or the two ends. In a narrow trench the earth is thrown onto the platforms from the two ends, and if the men in the bottom of the trench are trained properly they will learn to throw the earth over their heads [illegible] than by throwing it [illegible] This is a very important point.

In deep trenches where sheeting and bracing are not needed, special arrangements must be made for the platforms. In Fig. 1 we show a sketch of a platform which the writer has used with great success. It is cheaply made and readily [illegible], and will stand up in the trench, allowing men to work on it without being propped, and it can be moved without disturbing its [illegible]. It can also be used on either side of the trench. [illegible] boards [illegible] 1½-in. boards. If they [illegible] strong enough and [illegible] are easily handled.

In Fig. 2 is shown a sketch of a platform [illegible] for use in a narrow trench. The man shoveling in the bottom of the trench should stand with his back to the platform and throw the dirt over his head. Such a platform must be moved more frequently than the one shown in Fig. 1, and it is also more costly to move.

A man working in the bottom of a deep trench or pit should not be made to throw dirt more than about 6 ft. [illegible] from 6 to 10 ft. The reasons for this [illegible] a given height [illegible] Then everything should be made easier for the man in the bottom of the excavation, for [illegible] than is done by those working in the bottom of the trench. Thus the cubic yardage per man per day is governed by the man working in the bottom of the excavation. Figure 1 shows the platform 6 ft. above the bottom of the trench. If the work is properly handled this height should never be exceeded, but in Fig. 2 the platform is made but 1½ ft. above the bottom of the trench. This is necessary as the platform has to [illegible] that he would do less work. If the platform is made higher it will [illegible] be moved oftener.

When a second platform is needed the [illegible] between the lower and upper one may be made 5 ft. and the men will do efficient work. When the earth is thrown onto the ground [illegible] boards should be laid down to receive the earth, as the men will [illegible] If the boards are nailed together with cleats or battens they serve their purpose much better.

In narrow trenches two men in the bottom can excavate and throw onto a platform enough material to keep one man busy, but in a wide trench [illegible] platform. [illegible] should be put to work in the bottom of the trench.

[illegible]

Wet Trenches and Ditches.—The unwatering of trenches and ditches is of [illegible] importance. [illegible] it is only possible to excavate a foot or two before ground water is encountered. This water when it [illegible] large enough [illegible] trench [illegible] men, and also with the working of some kinds of trench excavating machines, generally making necessary the lining of the trench with sheeting, and also the pumping out of the water.

To excavate such trenches two distinct methods can be used. The first method is to unwater the trench and ground and do the excavation in the dry. The other method is to pump in additional water and then excavate the material by the hydraulic process, that is to make a coffer dam of a short section of the trench and pump the material out of this section.

The first method is the common one. The unwatering of the trench and ground is accomplished in many different ways. When only a small amount of water occurs in a trench, the simplest way is to bale it out with buckets. To facilitate this and most other methods, a sump is excavated to allow the water to gather at one place. To prevent the water from seeping back into the trench and to save carrying it away by men, thus adding considerably to the cost, either a "V" or a box-shaped trough is made of boards to receive the water from the buckets and pumps and carry it well away from the trench. This method is both a slow and a costly one, even when the buckets are large ones and are raised from the trench by power. The writer has used buckets having a capacity of about 25 gallons. Baling of water should only be done when there are but a few buckets of water to handle.

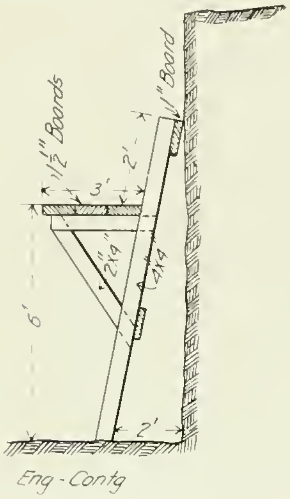


Fig. 1. Sketch of Platform Used to Throw Earth from a Wide Deep Trench.

The crudest pump to use for pumping water from a trench is known as a cellar, canal or bilge pump. It is a circular galvanized iron tube with a funnel shaped top and a spout, with a foot valve at the bottom. A long wooden handle with a leather cup or plunger on it is worked up and down in the tube and the water is thus raised. To start them they must be charged with a bucket or two of water. They are made in various lengths, ranging from 1 to 6 ft. up to 12 or 14 ft, although on special orders they can be obtained longer. After 18 ft. in length the work is very hard for men and is slow. The pumps are spoken of according to their lengths, an "8-ft. pump" is one 8 ft. long from its spout to the foot valve.

As the pump must be charged with several buckets of water it is evident that when only a few buckets of water have to be handled the baling method should be used, but any larger amount should be pumped. With all pumps, sumps should be dug in the trench. Cellar pumps wear out quickly, especially if kept in constant use. Sand and small gravel enter the tubes, injuring the foot valve and cutting the leather cup. The galvanized tube also becomes unsoldered and leaky. When such pumps are used in any number on a job, a soldering iron and heater should be kept on the job, and also leather for cups, to repair the pumps promptly or else a number of them will always be out of commission. It is never economical to use this style of pump for high lifts or when much water is to be pumped, as their capacity is small, and men, even when working two on a pump, can only pump a short time before spelling themselves. When a fair amount of water collects in a trench but not enough to require a steam pump, a diaphragm pump should be used.

There are a number of different makes of this style of pump on the market, and they do very effective work for pumps operated by hand. The pump is a compact iron one and can be placed on a platform with two handles on each end of it, so that two men can pick it up and carry it from place to place, while one or two men lift up and carry the suction hose, to prevent it being dragged along the ground, often causing the pump to overturn, and, with bad luck which generally occurs, throwing the pump into the trench. A rope should be tied onto the lower end of the suction hose near the strainer, which facilitates dropping and raising the hose into and out of the trench. The ordinary length of suction hose is about 12 ft., but the pump will do efficient work in raising water 20 ft. or more. A long lever is used to operate the pump, which makes the work easier for the men, and unless it must be worked very rapidly to keep out the water, the man can spell himself somewhat at each stroke so as not to stop the pump for some minutes. One man can operate the pump, but two men, as a rule, are needed to keep a rapid flow of water out of a trench. But when much water is to be handled, then a power pump should be used.

Another hand pump that has found favor with many engineers and contractors is known as the double acting force pump. The smaller size has but one handle, while the larger ones have two handles. The motion in operation is to push the handles forward and then pull them back. They do good work when the water does not have to be lifted very high, but they are harder for a man to operate and are not as efficient as the diaphragm pump.

If a long stretch of trench is in very wet ground and there is a large flow of water, the only pump to use is one operated by other than man power. Under many conditions a steam pump serves the purpose. There are many kinds of these. The one which is the simplest and easiest rigged up is a steam ejector, sometimes called a steam siphon. A large amount of water can be handled with a 2 or 3-in. ejector, but an ejector consumes a large amount of steam, even heating the water it pumps, so if the pumping is to be regular and continuous, some other style of pump should be used.

Two other styles of pumps that are well adapted to trench work are the Pulsometer and the Emerson pump. They can be hung in the excavation or even supported on the side and will do excellent work, even if the water is muddy or contains some sand.

For trench work, especially for long trenches, steam pumps and also the boilers to supply the steam should be so mounted as to be quickly and easily moved. The pump, which should sit close to the ground, can be placed on heavy runners, and can be dragged over the ground with a good team of horses without injury. It is better to mount the boiler on wheels, however the writer has moved them on runners. The discharge pipe should always be run some distance from the trench. Engineers and contractors seem to forget that when water occurs in trenches, the ground is generally very porous, so unless the water that is pumped is carried well away from the trench a large percentage of it quickly goes through the ground back to the trench to be repumped. In a sandy soil the writer was once compelled to carry the water more than 200 ft. to prevent it appearing again quite rapidly in the excavation. Another mistake frequently made with steam pumps on this class of work is to carry the steam too great a distance from the boiler to the pump. It is difficult to have lagging on the pipe, although it can be lagged except at the couplings. With wet steam the efficiency of the pump is greatly reduced, while the fuel consumption is increased.

In order to save having a boiler and moving it frequently a gasoline pump can be used for unwatering trenches. The entire pump and water barrel for cooling the engine can be mounted on a platform and be moved with runners by dragging it along the ground. A diaphram pump can be rigged up to be operated by a gasoline engine. When only necessary to move pumps a short distance men can do the work with rollers and bars. However, boards should be thrown down as runners for the rollers, and the latter should be several feet longer than the platform is wide. The rollers should also have two holes bored through them at each end, so that the bars can be used easily.

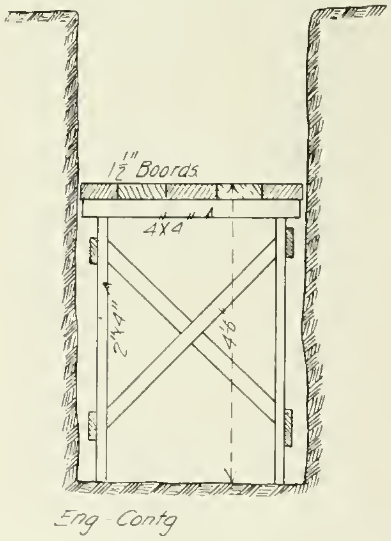


Fig. 2. Sketch of Platform Used to Throw Earth from a Narrow Deep Trench.

When an excessive amount of water occurs in trenches centrifugal pumps are used. These are either run by an engine with a belt or the engine is directly connected. For trench work a direct connected engine is preferred. Naturally with an engine a boiler must be used, so to save the boiler in towns and cities where electricity can be obtained, a direct connected motor is used. When a strainer or foot valve is not used on a pump of this kind coarse gravel and small cobbles can be pumped through it, but under any circumstances when the water in the sump

[illegible]

Cost of Plowing Farm Land With a Steam Traction Engine.

[illegible]

Roads and Streets Section

Note: This Section is devoted to methods and costs of road and street construction. It will cover road building in all its details, the construction of pavements, sidewalks and gutters, the testing and use of paving materials and the machinery and tools used in road building and paving.

The Theory of Economic Road and Street Design and Location.

X.

Designing an Economic Wearing Coat.—Since it is the function of the base to distribute the wheel loads over the subgrade, it follows that the wearing coat should have only sufficient thickness to provide for the wear due to abrasion between the periods of renewal. The logic of this inference is incontrovertible, yet the standard cross-sections of the majority of city pavements show very little evidence of an appreciation of the true function of a wearing coat. Certainly there is no logic in making any asphalt wearing coat 4 ins. thick, no matter how heavy the traffic that it is to carry. It is perhaps not so obvious that a brick pavement should not have a thickness of 4 ins. of brick, yet a little thought will make it clear that any such thickness is wholly uncalled for where the concrete base is properly designed.

Paving brick costs more than twice as much as concrete per cubic yard, or per inch of thickness per square yard. Hence not an inch of thickness should be given to the brick wearing coat for the purpose of load distribution over the subgrade, since concrete is a far cheaper material with which to perform that function.

So far as the performance of the other two functions of a pavement are concerned, the brick wearing coat need not have a thickness exceeding 2 ins. Hence the brick should be laid flat instead of on edge.

No pavement wears with perfect uniformity under traffic, for once a slight depression forms, due to slight variation in the material of the wearing coat, it tends to concentrate the wear at that place. Wheels drop into the slight depression with a pounding action; dust and water accumulate there, and, since the dust acts like so much emery under the wheels, the abrasion proceeds with greater rapidity wherever there is a depression.

Brick pavement is no exception to this rule of irregular wear, and, if the bricks differ even moderately in uniformity of burning, there is a decided tendency to wear irregularly. On a brick pavement subject to a heavy traffic for ten years the average loss in thickness had been ¾ in., but there were innumerable places where the loss had been 2 ins., and the entire pavement had therefore become so rough as to be unfit for further use. To provide for a heavy traffic giving such wear, it is advisable to lay a brick wearing coat about 3 ins. thick; but this condition is exceptional. The vast majority of brick pavements are laid on streets where the wear from traffic would not reduce their thickness more than a fraction of an inch in a century. In such cases, the brick wearing coat should not be more than 2 to 2½ ins. thick, or 50 to 60 per cent of present standard 4 in. thickness.

Why Paving Blocks Are Set On Edge.—In the investigation of reasons for existing standards of engineering construction, it is always desirable to study the history of the evolution of existing designs. When stone was first used as a pavement it was laid flatwise in large slabs; but it was soon found that such slabs are easily tilted by any heavily loaded wheel that comes on one side of the slab. This trouble was overcome by breaking the slabs into smaller blocks and setting those blocks on edge. An added advantage was thus secured, for the closely spaced joints gave a better foothold to horses.

When bricks were substituted for stone blocks, it was perfectly natural to follow precedent and set them on edge also. So, too, it was natural to set asphalt paving blocks on edge, and this was the general practice until comparatively recently. About ten years ago the writer pointed out the economic folly of setting either asphalt blocks or brick on edge. He called attention to the fact that the joints in asphalt blocks entirely disappear after a few years of use, due to a sort of welding together under traffic. Therefore there can be no advantage claimed for narrow blocks, set on edge, as far as foothold is concerned. The writer also questioned the use of a "sand cushion" between the concrete base and the asphalt or brick blocks. A "sand cushion" is necessary in bedding stone blocks, due to their irregular thickness and irregular surface, but neither asphalt blocks nor brick require a sand cushion.

It is now the general practice to lay asphalt blocks in a thin bed of cement mortar, laying the blocks flatwise. The success of this practice demonstrates conclusively that paving brick should be laid in a similar manner.

Neither an asphalt block nor a paving brick can tilt up as does a large stone slab, due not only to their smaller size, but more particularly to their careful bedding and to the closeness of their joints. When properly laid, asphalt blocks and paving bricks are like a monolithic sheet of paving material, and are not in the least like the ancient stone slab pavements.

Determining the Economic Thickness of a Wearing Coat.—If a wearing coat 4 ins. thick costs $1.00 per sq. yd. (or $0.25 per sq. yd. per inch of thickness), and if the traffic is such as to cause a loss of 0.04 in. of thickness per annum, the annual cost of the wearing cost would appear to be.

$$\begin{aligned}\text{Wear} &= 0.04 \times \$0.25 = 0.01\\ \text{Interest} &= \$1.00 \text{ at } 4\% = \underline{0.04}\\ \text{Total} &\ \ldots\ldots\ldots\ldots\ldots\ldots \$0.05\end{aligned}$$

But, as a matter of fact, many kinds of wearing coats are entirely unfit for further use before they have worn down an average depth of 1 in., due to the wavey condition of the pavement. In such an event, the true loss due to wear would be four times that above given, for, when 1 in. of wear has occurred, the entire 4 ins. has become valueless. This is true of most brick pavements. In such a case we have:

$$\begin{aligned}\text{Wear} &= \frac{4}{1} \times 0.04 \times \$0.25 = \$0.04\\ \text{Interest} &= \$1.00 \text{ at } 4\% = \underline{0.04}\\ \text{Total} &\ \ldots\ldots\ldots\ldots\ldots\ldots \$0.08\end{aligned}$$

It is evident that where the annual wear is slight, the interest item is relatively so large that it is poor economy to give any great thickness to the wearing coat for the purpose of lengthening the life of the pavement. Indeed, there is no economic justification for giving the wearing coat a greater thickness than is necessary to provide for loss due to a few years' wear plus the minimum thickness required to preserve the wearing coat from disintegration under the impact of wheels and hoofs.

Long life of any structure does not of itself prove economic design, and this is particularly true of the wearing coat of a pavement. The criterion of economic design of any given type of wearing coat is that the annual interest on the first cost plus the annual depreciation shall be a minimum. To apply this criterion it is essential first to know the amount of traffic, and, second, the consequent loss due to wear, neither of which is usually ascertained with any degree of accuracy at present.

Fortunately the wear on the vast majority of pavements is so slight that the main consideration is the first cost of the wearing coat. This, in turn, is a function of its thickness. Therefore, where the loss of thickness by wear is inconsiderable, only enough thickness should be given to the wearing coat to enable it to resist disintegration under the impact of wheels and hoofs. Few wearing coats will stand up under traffic if the thickness is less than 1½ to 2 ins., unless a monolithic, elastic coat made with a bituminous binder is used. What the minimum thickness of such a coat may be, we are unable to say now; but it is certain that even the thinnest asphalt wearing coats in use today are considerably thicker than they need be.

Testing The Resistance to Wear.—The only method commonly used for testing the resistance to wear is by the use of some sort of a rattler. Although the rattler test has its value, it is very unsatisfactory. A rattler, at best, serves only to indicate the relative value of different paving materials. It is a *qualitative* analysis —to use a chemical expression—and is not a *quantitative* analysis, even though it is given the appearance of being so. To illustrate: If stone for macadam shows a coefficient of wear of 10.5, what will be its loss in thickness per annum due to 1,000 loads hauled daily over it? This question can not be answered, except in the roughest manner, and then only by observing what the actual wear is upon the macadam in use during a period of years.

Beside this serious defect in the rattler test, we have one that is far more serious, namely, that no bituminous sheet pavement can be tested in the ordinary rattler. In view of the many millions of dollars annually invested in pavements, to say nothing of pavements already existing and requiring renewals, it is nothing short of amazing that the rattler test remains the only one in common use for determining the resistance to wear.

In St. Louis, about a generation ago, various classes of pavements were tested in the only manner that has ever appealed to the writer as being entirely rational. A stretch of pavement 3 ft. wide was built in a circle whose outside diameter was 16 ft. In the center of the circle was a vertical post whereon was pivoted a horizontal "sweep" (12 ft. long) to the outer end of which was hitched a horse. Fastened on this sweep was a wagon wheel that traveled on the circular stretch of test pavement. The wheel was loaded with 1¼ tons. In order not to rut the test pavement, the wheel was caused to slide slowly back and forth on an axle nearly 3 ft. long, and this was accomplished by using a long screw engaged by a pall, which automatiically covered the lateral thrust of the wheel.

The writer would suggest that a more satisfactory method of conducting tests of this sort would be to provide an electric motor driving several wheels, which are made to [illegible] "around" [illegible]. The wheels should not travel in the same track. Stretches of different kinds of pavement should be laid in the circle and should be kept in about the same state of cleanliness that would occur in actual use. The tendency of pavements to wear irregularly would be clearly shown by such a test, and the lack of uniformity of materials would be demonstrated in a manner impossible where paving parts are used.

In addition to the data of wear secured by such a test, valuable data would be gathered relative to the tractive resistance of pavements under various conditions, for by measuring the electricity required to drive the loaded wheels and by recording the number of round trips made by the wheels under given loads, accurate data as to tractive resistance would be obtained.

The destructive effect of pneumatic tires on various pavements could be accurately shown in this manner also.

In the June 2 issue of Engineering-Contracting some English data were quoted showing that macadam bound with a bituminous binder wears not nearly as rapidly as the ordinary macadam bound with stone dust. Remarkable illustrations like this would be disclosed by a test such as we have described, whereas the rattler test is wholly inadequate to show the wearing quality of a completed pavement.

(To be continued.)

Hints on Handling Labor in Road Work.

The greater part of the country road building in the Province of Ontario, Canada, is done by the day labor system under the direction of the Councils of the Townships interested. Recognizing this fact Mr. A. W. Campbell, Deputy Minister of Public Works, in his 1909 report on Highway Improvement in the Province of Ontario, has devoted a considerable portion of the report to giving the general principles of road making for benefit of these township road superintendents. We have abstracted as follows that portion of the report referring to the handling of labor.

Plan the work carefully and put men in such places and under such conditions that they will do their best.

Give such orders and instructions as are necessary to show the men what is expected of them.

Organize the work so as to get the best results from the men as a collective body, [illegible] effort.

Enlist the interest of the men so that they will work with their heads as well as with their hands.

Start work promptly each day, and do not stop before the proper time.

Pay workmen promptly, and carefully avoid errors in the amount paid. Nothing will so tend to discourage work as irregularity in the payment of wages.

The cost of roads is made up chiefly of the cost of labor, including hauling. Very little is spent on material alone. Grading and draining are almost wholly a matter of labor. Gravel pits cost very little, but teaming gravel, handling it in the pit and on the road, is where the cost lies. The cost of broken stone, [illegible], is the cost of labor for quarrying, crushing, hauling and spreading.

To build a road cheaply means a proper direction of labor. [illegible] the most [illegible] possible by directing well every labor [illegible] to the best advantage.

Designate certain men for certain work, and keep them at it until there is no more of that kind of work to be done. Subdivide duties and give each man as few portions of detail [illegible].

Have the work well planned in advance and keep it going in an orderly manner.

See that every man is provided with proper tools and [illegible]. Do not use poor tools. It is cheaper to buy new ones than to lose the work of the men.

The number of men and teams should be so balanced that all can be kept steadily at work. Too many men and not enough teams, or too many teams and not enough men, mean that one or the other will be standing in idleness a considerable part of the time.

Teamsters should drive out of a gravel pit in regular order. They should not crowd one another in a small pit, so that some few can fill their wagons with good material while others have sods and boulders. There are enough of the latter on the road without paying for teaming them.

A day's work in hauling gravel or broken stone should be specified by the number of loads, according to length of haul.

Every load should contain a fixed quantity—usually 1½ or 2 cu. yds. It takes very little more time to go from the pit to the road with a yard and a half of gravel than with one-half a yard. The larger load represents a clear gain of the difference in cost of the loads. Specify the size of the wagon box, and number of loads constituting a day's work.

Labor saving machinery should be used wherever possible. This does not mean that there will be less work for men to do on the roads, but that more work can be done for the same outlay. The grading machine, wheeled scrapers, dumping wagons for gravel and stone, stone crushers, etc.

It is essential to effective work that a road superintendent or a foreman have the confidence and respect of the men under them. By maintaining this the superintendent and foreman should have their work well in hand; there should be no delays while the foreman or superintendent is wondering what to do next.

Control should preferably come from one man. [illegible] every man should feel an interest in his work. A foreman should give direct instructions to [illegible]. [illegible] the superintendent should [illegible] with the men by giving directions with his [illegible].

For the same reason a [illegible] should not give orders to a foreman [illegible] road superintendent. To work [illegible] the superintendent [illegible] the [illegible].

A road superintendent should not, as a rule, work with his men. It is his business to work with his head, not with his hands, and to see that the work is properly organized. He may occasionally have to [illegible] certain work, [illegible] cheaper in the long run. This rule applies to a foreman [illegible] according to the extent of the work and the number of the men under him.

Do not [illegible] to do the work of laborers. [illegible] as much work as a [illegible] man. Provide enough material or gravel for every [illegible]. Keep every man busy at his own class of work, as far as possible.

Have sufficient extra wagons and [illegible] so that teams and teamsters will not be kept idle while wagons are being loaded or unloaded. [illegible] the time of teams and [illegible].

[illegible] men should be kept busy [illegible] such as [illegible].

As far as [illegible] the superintendent and foremen should exert careful effort to [illegible] every work as directly as possible.

Good [illegible] in the handling of [illegible] and speed in [illegible]. Do not over-crowd the work with men and teams. Have a foreman or superintendent who can organize. That is [illegible].

Wherever [illegible] competition. This [illegible] greater speed and better quality of work [illegible]. [illegible] a working [illegible] equal number of [illegible] as regards speed and quality of work.

Where the [illegible] may be divided [illegible] of the [illegible].

If two or three miles of road are to be built [illegible] may be divided [illegible] the work to be done [illegible]. Organization [illegible] to each case, adjusting the [illegible] to the class of work, distance from the quarry or gravel pit, the number of men and teams available, etc.

The same principle may be applied to the work of teams. Extra pay may be given for the large loads, the greatest number of trips, [illegible]. [illegible] superintendents have been known to [illegible] a good [illegible] of loads.

In a similar manner, if two [illegible] may be [illegible] a road [illegible] of the [illegible] reported to the [illegible] at [illegible].

Wherever a [illegible] that [illegible] better results can be secured [illegible] a good [illegible] their work.

Unclassified and General Articles

Note: This section is devoted to methods and cost articles on construction work not properly coming under any of the preceding classifications.

Caisson Disease and Its Prevention.

BY HENRY JAPP, M. AM. SOC. C. E.

(Never probably were more elaborate provisions employed for handling caisson disease than were employed by the contractors for the East River tunnels of the Pennsylvania R. R. at New York city. The foresight of the contractors in this respect was repaid not only in credit for humane feelings, but by the defense which it furnished against the very vigorous attempt made by the labor unions at one time during the work when fatalities were frequent to arouse public sentiment against, and invite official prosecution of the contractors for negligence and inhumanity in the care of their compressed air employes. In a recent paper prepared for the American Society of Civil Engineers Mr. Henry Japp, one of the engineers on the work, describes the methods employed to reduce fatalities from caisson diseases on the tunnels mentioned. This paper is unique as compared with most of the previous discussions of the subject in that it is written from the viewpoint of an engineer who realizes the practical conditions that must be met in tunneling under compressed air and who appreciates that the question of importance to the engineer and contractor is how to prevent attacks of the disease and not so much how to treat and cure it after it occurs. In these respects we consider this paper to be perhaps the most practically useful and instructive which has ever been published on caisson disease.—Editors.)

The prevention of caisson disease has not received as much attention as its cure, the general opinion being that it cannot be prevented. In forming an idea as to the possibility of its prevention, something may be learned from Nature's method of carrying out work by the aid of living organisms under air pressure.

First let us inquire whether Nature has a sufficient range of air pressure to make it necessary for a capacity to sustain variations without injury. The highest altitude on this earth is Mount Everest, 29,000 ft. above the level of the sea, and the deepest mine is Tamarack No. 3 Shaft, of the Calumet and Hecla Mines, 4,407 ft. below sea level.

The curve on Fig. 1 shows the absolute air pressure at various altitudes between these extremes. The total difference of 12½ lbs. per sq. in., or from 9¾ lbs. below atmospheric pressure at sea level (viz., 14.7 lbs.) up to 2¾ lbs. above normal, is considerable.

Mount Everest has never been ascended, but an elevation of 20,000 ft. has been reached, and men can live in comfort at an altitude of 7,000 ft., as in Mexico City, which has an air pressure of 3½ lbs. per sq. in. less than at the coast. Such a change of pressure is quite noticeable to those whose Eustachian tubes are closed, and, although the range of pressure is insufficient to produce caisson disease, yet travelers have complained of discomfort, not unlike a very mild attack, after a rapid journey by rail from Vera Cruz to Mexico City.

Eagles are known to go to great heights beyond the range of human vision, fish are capable of going to great depths in water, and beasts of prey roam from the mountain side to the valleys far below. With each descent these creatures have undergone compression, and with each ascent decompression.

It will be noted that Nature has no time limit for immersion under increased pressure, and the application of pressure is a much speedier and easier operation than that of decompression; and, while the compression is down-hill and attained with little effort, the decompression can only be attained by the continuous effort of climbing, and, in long ascents, with frequent rests or by stages. This is surely a forecast of the stage-decompression theory.

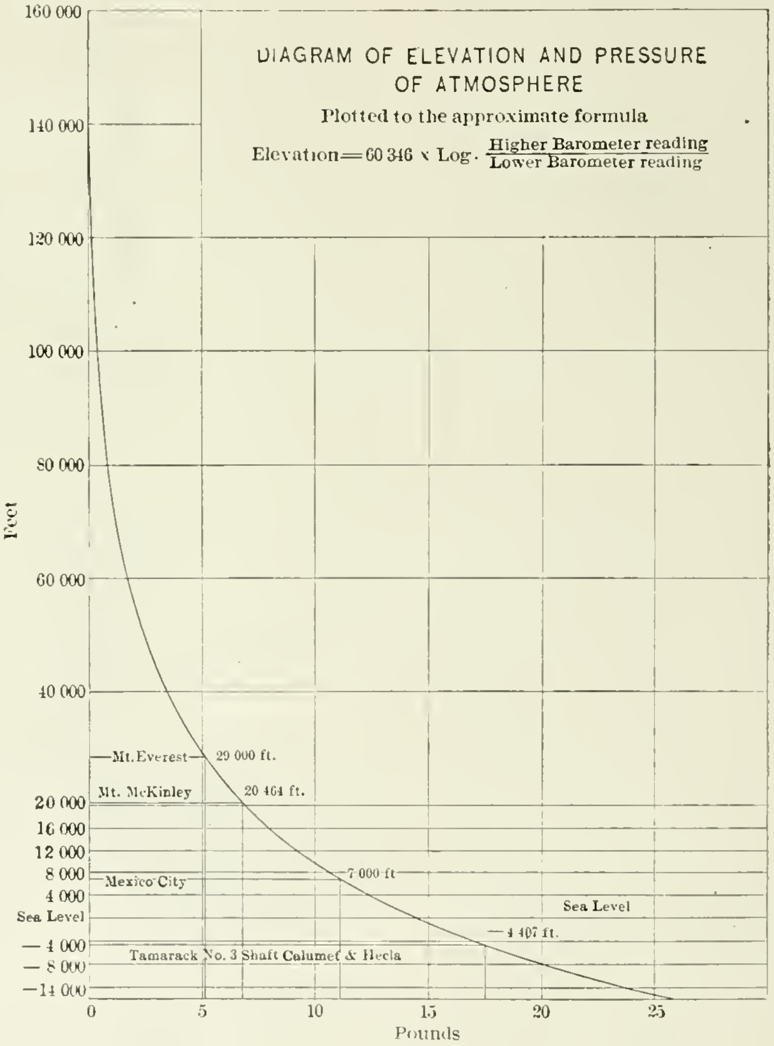


Fig. 1. Diagram of Elevation and Pressure of Atmosphere.

From Nature then, our best teacher, we learn that the time taken to enter the air-chamber may be short, the time spent in the air-chamber may be long, and the rate of coming out must be slow and accompanied by exercise.

In early compressed-air work engineers were confronted with caisson disease, and have long been striving for a remedy. Men of observation noted first that lock tenders who made frequent entry to the air-lock for short visits were much more immune from the malady than workers who stayed for a full shift, and from this argued that shortening the time in the air-chamber would be a safeguard, and, as higher pressures were used, the hours continued to be shortened until it was thought that half an hour at a maximum of 50 lbs. gage pressure was the limit of human endurance.

As the number of compressed-air works increased, so the workmen gained in experience, and it was noted that workmen of experience who suffered from the painful forms of caisson disease relieved the pain by re-entering the air-chamber.

About 30 years ago Paul Bert advanced the theory that caisson disease was caused by the nitrogen of the air being dissolved in the blood. He advocated slow decompression, suggesting 30 mins. for 2 to 3 atmospheres (15 to 30 lbs. gage pressure) and 60 mins. for 3 to 4 atmospheres (30 to 45 lbs. gage pressure). Since his time many writers and experimenters have followed in his footsteps, but it was not until Dr. Smith, of New York, suggested that a recompression chamber would act as a remedy, and E. W. Moir, M. Am. Soc. C. E., of London, without knowledge of Dr. Smith's prior suggestion, actually built a medical air-lock, or recompression chamber, in 1890, on the old Hudson Tunnel, New York, that any reliable cure for the trouble was discovered. Figure 2 shows the medical air lock designed by Mr. Moir, of which six were used in the East River tunnels of the Pennsylvania Tunnel & Terminal R. R.

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*A paper presented to the American Society of Civil Engineers and published in the Proceedings for April, 1909, p. 378, Vol. XXXV.

It was then found that if a man suffering from caisson disease, in any of its many forms, varying from unconsciousness and paralysis to an acute pain in the limbs, was quickly recompressed and allowed to decompress slowly, in many cases a cure resulted, but not always.

This went to prove that the disease was a mechanical one, and was caused by the dissolved air in the blood and tissues becoming liberated in the body in the form of expanding bubbles which [illegible] caused pressure on the brain around the spinal cord, or frothed up the blood and stopped the circulation and heart action.

Much has been done since the introduction of the medical air lock. The percentage of serious disease [illegible] the air of the working chamber has been kept within safe limits, [illegible] have been treated [illegible] the air [illegible] to the chamber and the workmen have been well cared for, but still caisson disease claims its victims, and engineers consider this inevitable.

The erratic manner of the disease baffles doctors and engineers alike. Men who have worked for months in high pressures for the regulation shift without suffering have been suddenly attacked and [illegible] [illegible] have worked for 12 hours at a time and have suffered [illegible] passed away.

The [illegible] & Sons, Inc., on the East River tunnels contract for the Pennsylvania Tunnel & Terminal R. R. Co., New York, were [illegible] compressed air [illegible] strange disease.

When these tunnels were commenced in 1904 the knowledge of compressed air at the disposal of the contractors was quite extensive and included the long experience of Alfred Noble, Past-President Am. Soc. C. E., in caisson work in the United States, and Mr. E. W. Moir's experience on the Forth Bridge caissons, the old Hudson Tunnel and the Blackwall tunnels and [illegible]

[illegible] the following rules [illegible]. No workman was allowed to enter the air chamber without a physical examination by

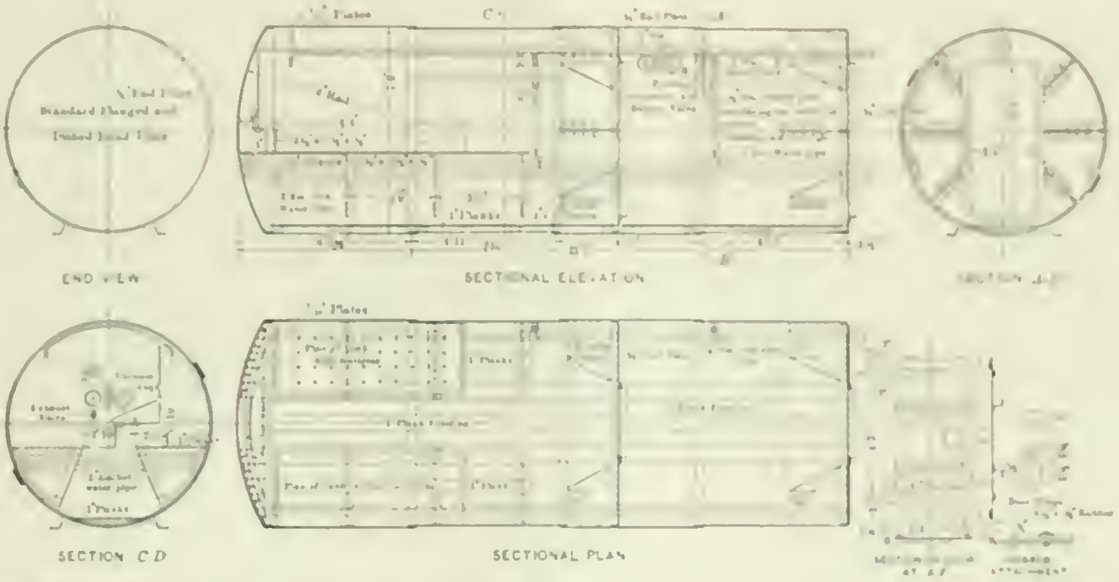

Fig. 2. Medical Air Lock Used in the East River Tunnels of the Pennsylvania Tunnel and Terminal Railroad.

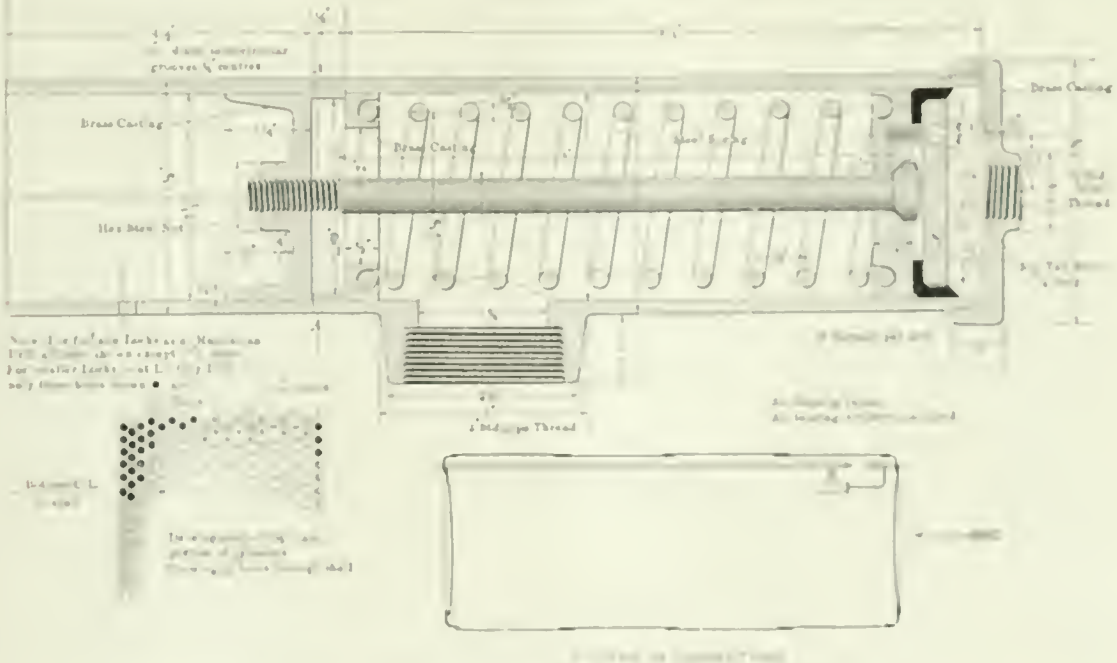

Fig. 3. Automatic Constant Rate Compression Valve

the qualified medical officer of the contractors. Sound physique was the chief requirement. The men were cautioned not to enter the air on an empty stomach, to wear warm clothing on coming out, and to drink hot coffee.

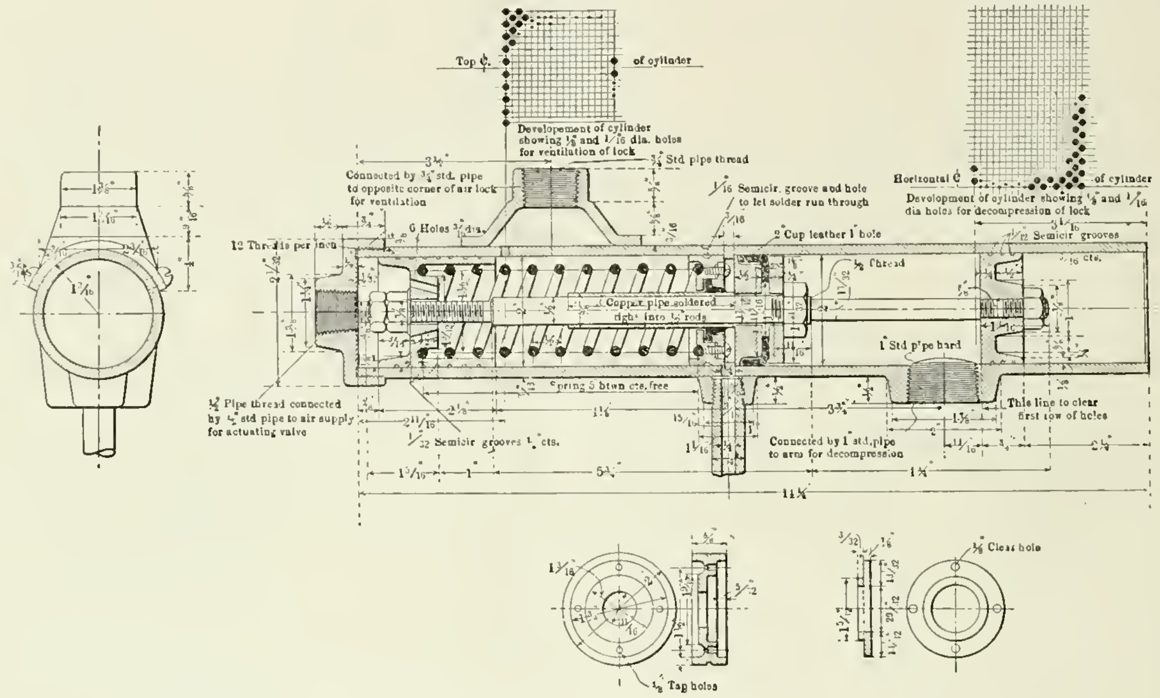
Top ℄. of cylinder
Developement of cylinder showing ⅛ and 1/16 dia. holes for ventilation of lock
3½
¾ Std pipe thread
Connected by ¾ std. pipe to opposite corner of air lock for ventilation
1/16 Semicir. groove and hole to let solder run through
3/16
6 Holes 3/32 dia.
12 Threads per inch
2 Cup leather 1 hole
Horizontal ℄ of cylinder
Development of cylinder showing ⅛ and 1/16 dia holes for decompression of lock
3 1/16
1/32 Semicir grooves
⅛ Thread
Copper pipe soldered tight into ½ rods
1 Std pipe hard
Spring 5 btwn cts. free
½ Pipe thread connected by ½ std pipe to air supply for actuating valve
2 11/16
1/32 Semicir grooves ¼ cts.
1 1/16
Connected by 1 std. pipe to arm for decompression
This line to clear first row of holes
1 5/16
1
5¼
1¾
2½
11⅛
1 3/16
⅛ Tap holes
⅛ Clear hole

Fig. 4. Automatic Constant Rate Decompression and Ventilating Valve.

The time worked in the air-chamber was limited to 8 hours with half an hour off for lunch, up to 32 lbs. gage pressure, and two spells of 3 hours each with 3 hours rest between for pressures from 32 to 42 lbs. and two spells of 2 hours each for pressures greater than 42 lbs. with 4 hours rest between, with no limitation as to decompression. Two medical air-locks were installed on each side of the river, well-warmed dressing rooms were provided for the workmen, and there were covered gangways for access to the shafts.

The air was cooled before delivery to the tunnels, and samples were taken in the tunnels by Mr. Noble's engineers and analyzed daily. The air was regulated so that the carbon dioxide did not exceed 10 parts in 10,000, and the tunnels were kept in a sanitary condition.

Owing to the grade of the tunnels being so deep on the Manhattan side of the river, the air pressure very quickly rose to 36 lbs.

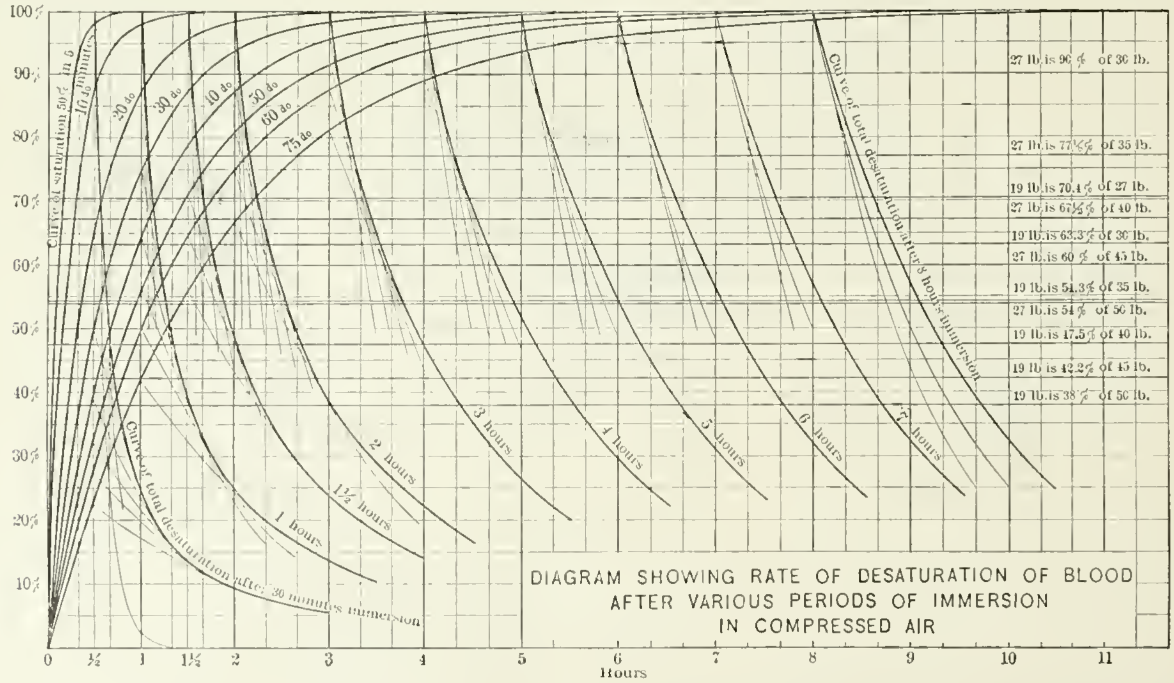

Fig. 5. Diagram Showing Rate of Desaturation of Blood After Various Periods of Immersion in Compressed Air.

Practically no cases of bends occurred until the pressure reached 29 lbs. and then, within a few days of each other, two men died. These men had entered the air-chamber without being passed by the doctor. Then it became necessary to post outside each air-chamber a guard whose duty it was to keep out of the tunnel men who had no doctor's pass. At this time, reliance could not be placed on the tunnel foremen, as they were likely to be absent from work, and new men had to be selected each day.

For many months after the work started, while the men were being seasoned, the tunnel gangs and foremen were in a state of change, owing to the difficulty of getting good men and the frequent absences due to caisson disease, and it was a long time before an efficient organization was built up.

As the tunnels were driven deeper beneath the East River the pressure quickly rose and ultimately reached 36 lbs. gage pressure, with only one set of air locks in operation, but even the change at 32 lbs. from one shift of 8 hours to two shifts of 3 hours each gave no relief, and cases of bends, sometimes fatal, continued all the time.

It was not long after 27 lbs. was reached that the more sensitive members of the staff found that it did not pay to come out quickly, and at 30 lbs. pressure it became a custom to take about ½ min. for each pound. After one or two additional fatal cases occurred it was decided to limit the workmen to approximately the same rate of decompression, or actually 15 mins. for 35 lbs. pressure.

Many of the men complained that taking so long to decompress gave them caisson disease, and it was difficult to compel them to take long enough. The guards at the entrance to the tunnels had now to record the time taken to decompress, and as the workmen frequently used the lower muck locks as well as the upper man lock, it was impossible to tell when decompression commenced owing to the noise of exhausting air. Therefore it became necessary to run a small ¾-in. pipe from the exhaust pipe of each lock to the cabin in which the guard was stationed, a whistle was attached, and a small ball of cotton was suspended by a light string over each pipe. The clerk, noting when the ball was puffed off for each lock, booked the workmen off as they left the lock. The material locks were fitted with inner material valves and, in addition, man valves of smaller size, and a pressure gage and a clock were fixed in each air lock.

As the guard had already booked the men as they entered, he could tell if any were exceeding the regular working shift, and his record was valuable for checking the timekeepers. This rough method of checking the duration of the decompression was quite good enough for the purpose. An attempt to improve it was made when a 12-in. Crosby recording gage was installed on one air-lock, but it was ineffectual because the air-lock was often sent out or decompressed with no one inside, and this complicated the record, which was much too small and involved considerable trouble in locating the record of decompression for individual gangs. No doubt a suitable recording instrument could be devised for this special purpose.

The effect of lengthening the decompression period to 15 mins. reduced the number of cases of bends, and no doubt prevented many fatal ones, but they still occurred. As the tunnels had many months to run at high air pressures, the question was: What else can be done to prevent them?

The writer, in coming out of the tunnel with the workmen, observed that the rate of decompressing was most irregular. One lock tender would allow the air to escape slowly until the 15 mins. were almost exhausted and then, by opening the valve, would let off the remaining pressure very quickly. Others would reverse the process and exhaust quickly and then keep the men under 2 or 3 lbs. until the time expired. To avoid this a simple decompressing valve was designed (Fig. 3) which gave a uniform decompression from 35 lbs. to atmosphere in 15 mins. A somewhat similar one (Fig. 4) was designed for the medical air-lock for 1 hour decompression for 35 lbs., with an automatic ventilator attached.

These valves certainly improved conditions, but still fatal cases occurred. After the first valve was under operation the writer's attention was called to "Modern Tunnel Practice," by D. McN. Stauffer, M. Am. Soc. C. E., wherein a description is given of a needle decompression valve used on the air-locks at the Kiel Dry Dock Works in Germany. A similar valve was also used for compression. On entering the lock the air was admitted at the rate of 1½ lbs. per min. and was decompressed at the rate of ⅝ lb. per min., or for 35 lbs. gage pressure 24 mins. for entering the air and 56 mins. for leaving. This needle valve was often frozen up, but otherwise worked well.

Such speeds seemed abnormally too slow, and Mr. Stauffer in his book states that "these rates would be deemed excessively slow in American caisson practice." No date is given for the Kiel Dry Dock work, but presumably it was under way in 1901.

It was not thought advisable to increase the time of decompression at that time, but preliminary trials under air pressure in the tunnels for 1½ hours were then tried for green men, followed by a second medical examination after decompressing in 15 mins. A few men were eliminated by this test, and one case of permanent paralysis resulted from the test in 34 lbs. gage pressure. Fresh starters were made to stay in the tunnel for one-quarter of a shift for the first half, and if no caisson disease followed they were allowed to work for the second half. This proved a good safeguard.

On Nov. 8, 1905, a second bulkhead was put in operation in one of the tunnels, and the pressure between the two bulkheads was reduced to 17 lbs. gage. The number of cases of disease was very small for that tunnel, and as soon as possible additional bulkheads were placed in all four tunnels. The result was to have been expected from the experience in other tunnels where two bulkheads were used; the exercise of the long walk between bulkheads, at low pressure, seemed to assist in driving off the bubbles of air from the blood.

The workmen were allowed to decompress from 35 to 17 lbs. as quickly as they desired. Then they walked the 500 ft. along the tunnel under 17 lbs., taking at least 2 mins., and then decompressed from 17 lbs. to atmosphere in 10 mins., so that in all about 16 mins. were occupied in decompressing. When the lower pressure was less than 20 lbs. an 8-hour shift was worked, with ½-hour interval for lunch between bulkheads in low air pressure.

Just when it looked as if the double bulkheads with stage decompression had eliminated fatal and severe cases of caisson disease, two deaths occurred in physically perfect subjects.

In order to discover, if possible, the connection between the cases of disease and

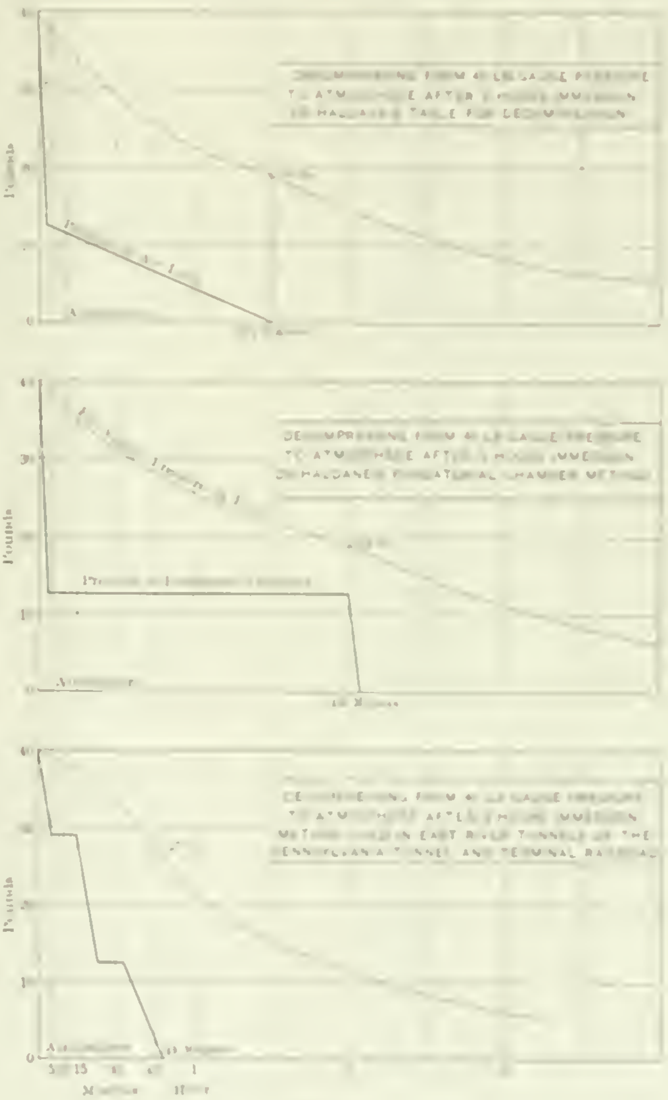

Fig. 6.

other things, charts were plotted by the medical staff for some months, showing the rise and fall of air pressure, hours worked, humidity, temperature, percentage of carbon dioxide, and number of green men in the tunnel, along with barometer readings, condition of weather, direction of wind, and number of cases of bends. The results were not very encouraging, but it was noted that the number of green men, the height of pressure in the tunnel and the number of cases of bends varied together.

The percentage of cases in air pressure of 31½ lbs. for 8-hour shifts was no more than the percentage in 32½ lbs. for two 3-hour shifts—in fact, it was, if anything, less for the longer shift. The decrease in length of shift added one extra gang of men, and probably many of these men being green accounted for this.

In November, 1906, Mr. Moir became acquainted in part with Dr. Haldane's work of investigation for the British Admiralty on "Deep Sea Diving," and ordered the decompressing valves changed so that the decompression was accelerated at the commencement of the operation, and slowed off toward the end. In October, 1906, the writer, endeavoring to find out the effect of sudden decompression, fitted an ordinary glass siphon bottle with a valve and pressure gage. This bottle was partly filled with water, and put under 36 lbs. air pressure for 12 hours. On suddenly releasing the pressure, no effervescence whatever took place, and only a very few minute bubbles were visible. The same thing was tried with the bottle partly filled with bullock's blood, with like results. Arguing that the placid surface of blood in a stationary vessel offered no such opportunity for dissolving air as occurs in the lung surface with the blood circulating, the siphon was again charged with 36 lbs. pressure, but was rotated for 24 hours under this pressure. The same result as before was observed on suddenly releasing the pressure; but, on closing the valve, the pressure recorded on the gage was about 1 lb. per sq. in. in less than 1 hour, and in 6 days a pressure of 13 lbs. was recorded, showing that the air dissolved in the blood came off very slowly.

If the cork of a bottle of aerated water is drawn quickly, it effervesces so violently that the water froths out of the neck of the bottle; but, if the gas is allowed to escape slowly, only a mild bubbling results. This in general is the theory on which slow decompression has been advocated in the past. The violence of the escape of carbon dioxide gas from aerated water, as compared with the escape of air from water released from pressure, is due to the greater solubility of carbon dioxide than air.

It was difficult to know what else could be done at this time in the way of eliminating caisson disease on the East River tunnels, and the cases of disease were certainly less frequent and less severe, although at long intervals fatal cases still occurred. The workmen, by this time, had become seasoned, and more seasoned men were now available from other works.

Dr. Leonard Hill read a paper on deep sea diving and caisson work, on Sept. 26, 1907, and exhibited the web of a living frog under a pressure of 20 atmospheres. On suddenly decompressing, bubbles were plainly visible in the blood vessels, multiplying quickly as they traveled along until the circulation was choked; on recompression the bubbles disappeared and circulation was resumed. He stated that he and Mr. Greenwood had been under an air pressure of 92 lbs. and had suffered no ill effects.

Dr. J. S. Haldane, on Nov. 29, 1907, read a most enlightening paper before the Society of Arts, in London, in which he gave the results of his investigation for the British Admiralty on "Deep Sea Diving."

He set forth very clearly the question of the solution of gases by the blood, fat, and tissues of the body, and attempted to determine the time taken to saturate the blood with the nitrogen of the air. He proved conclusively that the quantity of carbon dioxide adjusts itself to a constant percentage inversely proportional to the pressure in the alveoli, or air cells.

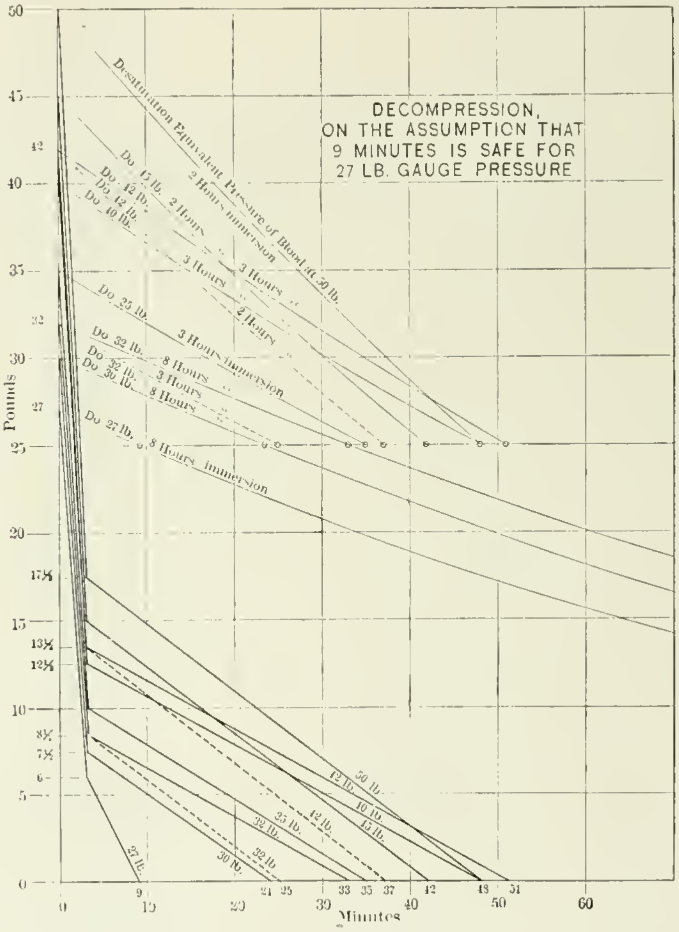

Fig. 7. Decompression, on the Assumption That 9 Minutes is Safe for 27-lb. Gage Pressure.

In atmospheric pressure, the percentage of carbon dioxide in the alveolar or expired air is 5.6 per cent, and at a pressure of 2 atmospheres, absolute, this is reduced to 2.8 per cent, so that the question of the percentage of carbon dioxide in the air of the working chamber is not important unless it approaches the percentage of carbon dioxide in the air cells of the lungs.

For instance, if the air-chamber is under an air pressure of 30 lbs. or 3 atmospheres absolute, the percentage of carbon dioxide in the air cells is 5.6 divided by 3, or 1.86 per cent; and, if the percentage of carbon dioxide in the air-chamber does not exceed 1 per cent no ill effects will arise. This is ten times as much as is generally specified, namely, 10 parts in 10,000, and greatly reduces the amount of compressed air necessary per man per hour, which can be calculated approximately from the following simple formula:

$$\text{Cubic feet per man per hour} = \frac{\text{80 cu. ft. permitted above normal air}}{\text{Percentage of rise of CO}_2}.$$

Thus, if 0.04 per cent is the CO_2 in the atmosphere, and the percentage in the tunnel is allowed to go up to 0.10 per cent, the air required per man per hour $= \frac{80}{0.06} = 1{,}333$ cu. ft.

Dr. Haldane has completely removed all difficulty of respiration and discomfort of divers at great depths through the application of this theory regarding the percentage of CO_2 by supplying the diver with the same volume of compressed air per minute at different levels instead of the same volume of free air per minute.

The question of ventilating compressed-air tunnels seldom arises, as the volume of air generally far exceeds the amount required for purity, on account of the tremendous leakage at the face, so that this is not nearly as important as is indicated by Dr. Haldane's investigation of the solubility of air by the blood and tissues of the body.

After demonstrating that the CO_2 is dealt with automatically, he shows that nearly all the oxygen dissolved by the blood is taken up chemically by the hemoglobin, but the nitrogen remaining is incapable of combination with the system, and is dissolved by the blood and tissues. These, therefore, become saturated with nitrogen during immersion in compressed air.

If saturation takes place quickly it will not matter how long a workman stays under air pressure; but, if slowly, then shortening of the working shift will be a safeguard.

The rate of saturation is the same as the rate of desaturation if compression and decompression are instantaneous; so that, by altering the time for decompression, it is possible to determine by experiment the rate of saturation and desaturation.

Dr. Haldane experimented with men and goats at high air pressures, with varying lengths of stay under air pressure, and with different speeds of decompression. From these he concluded that certain parts of the body, where the circulation is rapid and the number of blood vessels high for the mass of the part supplied, would be half saturated or desaturated in 5 mins., while other parts, with slight circulation for the mass, would require 75 mins. for 50 per cent saturation, especially the fatty parts, as fat is found to dissolve about six times as much nitrogen as blood.

Figure 5 shows the rate of saturation, on the basis of half saturation in various times from 5 to 75 mins. and curves of desaturation, if the decompression is instantaneous after varying times of immersion from ½ hour up to 8 hours.

It will be seen that 90 per cent saturation takes place in the slowest parts of the body in about 4 hours, and complete saturation for the quickest parts in about 40 mins., so that after 40 mins. immersion there is danger in too rapid decompression.

Dr. Haldane has noted that no serious cases of caisson disease have occurred for rapid decompression at a working pressure of 19 lbs. gage pressure, or 2.3 atmospheres, absolute. Therefore, he concludes that it is always safe to decompress rapidly to half the absolute pressure, or even to the absolute pressure divided by 2.3, without bubbles being liberated. Further, if the decompression for the remaining pressure is continued at such a rate as will keep pace with the rate of desaturation then the absolute pressure of nitrogen in the blood never exceeding 2.3 times the absolute pressure in the air-lock during decompression or after returning to the atmosphere, no symptoms will occur.

Table I shows the rates of decompression advocated by Mr. Haldane for caisson workers.

TABLE I.—Dr. Haldane's Rate of Decompression in Caisson and Tunnel Works.

Working pressure in pounds per sq. in.	Number of minutes for each period of decompression after the first rapid stage. After first 3 hours' exposure	After second or third hours' exposure, all included	After 6 hours or more of continuous exposure
18-20	2	[illegible]	[illegible]
21-24	3	[illegible]	[illegible]
25-29	5	[illegible]	8
30-34	6	[illegible]	9
35-39	[illegible]	8	9
40-45	[illegible]	8	9

If the pressure is 40 lbs. gage, decompress rapidly from 40 lbs. to $\frac{40 + 15}{2} = 27\frac{1}{2}$ lbs. absolute, or 12½ lbs. gage, in 5 mins. and then take 7 mins. for each remaining pound, viz., 12½ lbs. or 87½ mins. plus 3 mins. = 90½ mins. or 1½ hours in all for a 3-hour immersion, or for a 6-hour immersion, 115 mins. in all. The upper diagram on Fig. 6 shows this graphically.

It will be seen that if this rule is followed, the condition of the [illegible] pressure, being half the pressure in the blood is obtained. If uniform decompression for the same time were adopted the decompression would be too slow for the earlier part, would very much retard the desaturation, and would give a greater tendency to the blood than 19 lbs. [illegible] out of the air pressure.

It is obvious that where the air lock has any pressure in it the [illegible] takes place only in relation to that pressure, and, if one adopts Dr. Haldane's idea of keeping a portion of the [illegible] at half the absolute pressure for a [illegible] to act as a purgatorial chamber, where the men may wash and change while decompressing down to 19 lbs., we must have a new curve for desaturation [illegible] the time of decompressing, as will be seen by the second diagram on Fig. 6.

From this it appears that the tension in the blood does not reach 19 lbs. until a period of 123 mins. had been passed in the purgatorial chamber after 3 hours' compression.

It will be noticed that Dr. Haldane bases his theory of decompression on the fact that no cases of caisson disease are recorded for men working at gage pressures up to 19 lbs. or 34 lbs. absolute, and if it is safe to decompress suddenly from 34 lbs. absolute, to 15 lbs. absolute, it is safe to decompress suddenly from 50 lbs. absolute to 22 lbs. absolute, or from 35 lbs. gage pressure, to 7 lbs. gage pressure.

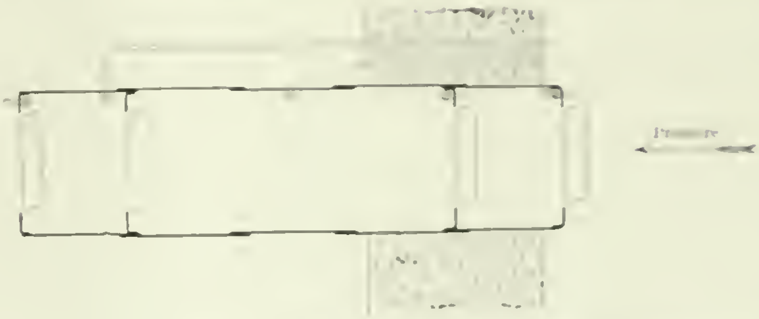

Fig. 8. Air-Lock With Middle Decompressing Chamber.

The question arises at once: Are the times suggested by Dr. Haldane practical? Many caissons of small dimensions are sunk under air pressures of 35 lbs. and to cramp men in a small air lock for 74 mins. is out of the question, and the fitting of large compartments in small vertical air locks, as used in building foundations in New York City, would be difficult. In tunnel work it would be easier, but the present method of rapid decompression is so radically different from Dr. Haldane's suggestion that it quite appalls one to think of taking so long.

The experience of many compressed air works is that up to 25 lbs. gage pressure there is very little trouble, and [illegible] the safe limit the times required to reduce the saturation in the blood to 19 lbs. is not so excessive for pressures of 25 to 30 lbs.

The horizontal lines on Fig. 7 show the [illegible] points for 27 and 20 lbs. in the blood [illegible] 45 to 50 lbs. and 15 lbs. gage pressure.

It will be noticed [illegible] parts of the body are only partly saturated in the first two hours of immersion and therefore the [illegible] comparatively less.

From Fig. 7 Tables II and III have been compiled; they show the times taken in rapid decompression [illegible].

If the decompression is slow, these curves will be flattened and a longer time will elapse before the saturation of the blood falls to the equivalent of 19 lbs. [illegible] as the case may be.

Figure 7 shows the curves of decompression from 27, 30 and 35 lbs. gage, after 8 hours' immersion, and for 42, 45, 48 and 42 lbs. gage after 3 hours' immersion, and 42, 45 and 50 lbs. gage after 2 hours' immersion, on the basis that it is safe to decompress from 27 lbs. gage pressure [illegible]. This reduces the saturation in the blood to the equivalent of 28 lbs. on reaching atmospheric pressure.

TABLE II.—Times [illegible] to fall to the equivalent of 19 lbs. gage pressure with instant decompression after various periods of immersion in compressed air.

No. of hours of immersion	Gage Pressure					
½ hour	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1 hour	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1½ hours	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2 hours	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
3 hours	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
4 hours	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
5 hours	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
6 hours	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
7 hours	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
8 hours	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

(The times in Table 2 allow for instant decompression; [illegible] for slow decompression.)

TABLE III.—Times [illegible] for pressure in blood to fall to the equivalent of 27 lbs. gage pressure with instant decompression after various periods of immersion in compressed air.

No. of hours of immersion	Gage Pressure					
½ hour	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1 hour	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1½ hours	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2 hours	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
3 hours	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
4 hours	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
5 hours	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	61
6 hours	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
7 hours	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
8 hours	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

(The times in Table 3 allow for instant decompression; [illegible] for slow decompression.)

Table IV is taken from Fig. 7, and in part is [illegible] by the experience on the [illegible] caisson disease [illegible] should be [illegible] with [illegible].

TABLE IV.—Decompression [illegible]

[illegible]

Some time after reading Dr. Haldane's paper and studying his theory, it became necessary to [illegible] pressure [illegible] nels to 40 lbs. gage. It was possible to make the workmen pass through three sets of air-locks on leaving the tunnel. The inner chamber was kept at 40 lbs., the intermediate chamber at 29 lbs., and the outer chamber at 12½ lbs.

The men were ordered to take 5 mins. in the first lock, 8 mins. in the second lock, and 15 mins. in the third. There was a distance of approximately 1,000 ft. between each pair of locks. Walking this distance and gathering in the stragglers generally required 10 mins. to each chamber, so that, in all, 48 mins. were taken to decompress from 40 lbs. to atmosphere. No severe or fatal cases resulted, and little time was lost by the men through caisson disease, the cases being only slight. Under this pressure 330 men were employed for 36 days, working 3 hours on, 3 hours off and 3 hours on. It is true that no green men were used on this work, as there were plenty of experienced air men available at that time.

The third diagram on Fig. 6 shows the desaturation curve and rate of decompression, leaving the saturation of the blood equivalent to 27 lbs. on reaching atmospheric pressure. This result bears out in part the periods of decompression of Table IV, and, if a more rapid passage had been made through the first and second locks, probably a better result would have been attained, as the equivalent pressure of the blood would have reached 25 lbs. on coming out, as shown by Fig. 7, instead of 27 lbs.

In caissons or tunnels with but one lock, it is a difficult problem to allow workmen as long a time as Table IV indicates, as no one can enter the air-lock during decompression. One method of overcoming this difficulty would be to provide a lock with two small end chambers and a larger center chamber, four doors in all being necessary. Anyone making a short visit to the caisson could pass through without disturbing the pressure in the middle decompressing chamber. Figure 8 is a diagram of such a lock with connections.

Some one has suggested, for diving bells and caissons, a detachable chamber like a boiler which the men could enter, and thus take as long as necessary to decompress.

The men on the East River tunnels rebelled against 15 mins. for decompression, but, after putting the responsibility up to the foremen, in time they found that it was a safeguard and voluntarily lengthened the time to 20 mins. and gladly submitted to 48 mins. for 40 lbs.

The death rate due to caisson disease was comparatively small, averaging 19/100 of 1 per cent for the whole of the compressed-air work, and, from the experience gained, it would in all probability have been much higher if the decompression had not been lengthened.

The fact that the only recognized cure for caisson disease is recompression in a medical air-lock followed by slow decompression, is a powerful argument in favor of slow decompression, and where it is at all possible, in future works, regulated decompression will in all probability be adopted.

In caissons with small air-locks the volume of air remaining when the lock is full of men is very slight, and very rapid decompression takes place. The workmen have a good opportunity to become seasoned in a caisson, as the pressure begins at 1 or 2 lbs. and gradually increases day by day as the caisson sinks, and the highest pressures are required for but a few days.

On the East River tunnels two caissons were sunk to a final pressure of 33½ lbs. and very few cases of caisson disease occurred, none of which was fatal although the decompression was rapid. On the other hand, on account of the tunnels on the Manhattan side starting out at a high pressure, the men had no chance to get seasoned, and many cases occurred, though the time of decompression was regulated, but not to such an extent as Table IV indicates.

Thus far, practically, no grandfatherly legislation hampers engineers in the United States in compressed-air work, but such legislation is threatened, and engineers should be prepared to guide it. The engineer is confronted with conflicting testimony on all sides, and, though his experience shows that some men are capable of rapid decompression without injury, he also knows that many men are injured. Because a few men can for a time rashly take the risk, shall he eliminate good men from compressed-air work by putting them to such a test without endeavoring to make it safe for all who are physically sound?

Personals.

Mr. B. B. Kelliher, chief engineer, Grand Trunk Pacific Ry., has transferred his headquarters from Montreal to Winnipeg, Man.

Mr. J. S. Calhoun, Jr., has been engaged as superintendent for James Devault & Son, in charge of the erection of the new post-office at Moline, Ill.

Mr. E. C. Crum, civil engineer and constructor, Frederick, Md., has been appointed chief engineer of the Washington, Frederick & Gettysburg Ry. Mr. Crum will continue his private practice in connection with his new duties.

Messrs. Herbert S. Crocker and Milo S. Ketchum, Ms. Am. Soc. C. E., announce that they have formed a partnership under the firm name of Crocker & Ketchum, Consulting Engineers, with offices at 811 17th St., Denver, Colo.

Mr. St. George H. Cooke, Assoc. M. Am. Soc. C. E., has changed the location of his office from the Cambridge Building, Chester, Pa., to the Real Estate Trust Building, Philadelphia, where he will continue to conduct a general civil engineering practice.

Mr. George C. Whipple, of New York city, has been retained by the Water Board of Baltimore to make a sanitary survey of Lake Roland and the Jones Falls watershed in connection with the preliminary work for the new $5,000,000 reservoir.

Mr. Walter J. Briggs has resigned as director, secretary and treasurer of Ernst Wiener Co., of New York city, and Mr. Arthur P. Van Schaick has been elected vice-president and director of the same company with headquarters at Chicago, Ill.

Mr. John F. Stevens, M. Am. Soc. C. E., has resigned as vice-president of the New York, New Haven & Hartford R. R., and has been engaged by the Great Northern Ry., to investigate and report on water-power facilities for that company in Montana and Washington.

Messrs. Condron & Sinks, 1214-5 Monadnock, Chicago, Ill., announce that they have discontinued their connection with the Corrugated Bar Co. of St. Louis, Mo., and will devote their attention exclusively to professional engineering, as consulting, designing and supervising engineers for railroads, municipalities, architects and contractors, special attention being given to reinforced concrete and steel structures.

Mr. H. E. Warrington, Chief Engineer of the Cincinnati, New Orleans & Texas and the Alabama Great Southern railways, having resigned, the office of Chief Engineer is abolished. Mr. Curtis Dougherty has been appointed Engineer Maintenance of Way, with office at Cincinnati, reporting to the General Manager, and Mr. B. Herman has been appointed Engineer of Bridges, with office at Cincinnati, reporting to the Engineer Maintenance of Way.

Victor O. Friday, a member of the Friday Contracting Co., Fitzsimmons Bldg., Pittsburg, was almost instantly killed on June 9, at Hulton, Pa., where his firm is building the piers and shore abutments for the new Oakmont bridge across the Allegheny River. Mr. Friday was standing under a derrick which was raising heavy stones from a barge, when the boom of the derrick broke and, falling, struck him before he had time to move from the spot on which he was standing. He was 32 years old and was a son of the founder of the above firm.

Catalogs Worth Having.

Engineers and contractors should have on file the latest catalogs of machines, tools and supplies that they use. In sending for catalogs reviewed or advertised in this paper, you will confer a favor on us if you will write direct to the advertisers and state that you saw the catalog mentioned in ENGINEERING-CONTRACTING. If you are in the market for tools, machinery or supplies, tell us and we will notify promptly the leading manufacturers.

No. 1280. **Road Rollers.**—The Kelly-Springfield Road Roller Co., Springfield, O.

The steam road roller described and illustrated in this 38-page pamphlet is generally known to contractors for road work. Some of the illustrations are interesting as showing the use of road rollers for hauling plows for plowing up old roadway. Views and description are also given of the Springfield scarifier.

No. 1281. **Crushing and Road Machinery.**—Climax Road Machine Co., Marathon, Cortland Co., N. Y.

This is a well written descriptive pamphlet of 24 pages illustrating and describing the line of rock crushers, portable crushing plants and road machinery manufactured by the above well known firm. The catalog is especially interesting for the full description which it gives of the construction of the several machines illustrated.

No. 1282. **Alaska-Yukon-Pacific Exposition.**—American Locomotive Co., New York city.

This 31-page pamphlet illustrates and describes the joint exhibit of this company and the Atlantic Equipment Co. at the Exposition now in progress at Seattle, Washington. The exhibit consists of a Rotary snow plow, built for the Chicago, Milwaukee & Puget Sound Ry.; two locomotives, each representing the builder's new standard design of its type; one, a six-coupled tank or 2-6-2 type locomotive for logging service, and the other, a 10 x 16 in. four-wheel saddle tank contractor's locomotive; an electric motor and trailer truck, built for the Southern Pacific Co., and a new model, Class 45-16-2½, Atlantic steam shovel. A separate chapter is devoted to each equipment exhibited in which is illustrated the machine itself, and the special features of the design are briefly described. Reference is also given in each chapter to other of the company's publications presenting different designs and types of the same class of equipment; and on page 31 is an index of all the catalogs in print issued to date by the two companies.

No. 1283. **Gas and Gasoline Engines.**—Olds Gas Power Co., Lansing, Mich.

This is one of the very best descriptive catalogs that we have ever seen. It presents the merits of the Olds Type A engine in its various forms and sizes. The construction of the engine is clearly described and the various structural and operation advantages claimed for it are fully and clearly presented. One of the notable features of the pamphlet is the illustrations showing the engine connected up to various machines such as concrete mixers, centrifugal pumps and agricultural machinery.

No. 1284. **Steel Forms.**—George W. Jackson, Inc., Chicago, Ill.

This pamphlet describes a system of steel forms for walls and arches with illustrations of their application to different purposes. The steel centers for arches are particularly interesting.

No. 1285. **Concrete Buildings and Other Construction.** — Colorado Portland Cement Co., Denver, Colo.

This 50-page pamphlet briefly describes the merits of the different kinds of office and factory buildings. Devotes about 30 pages to the recommendations of a joint committee of the various national associations interested, which is a valuable synopsis of the present knowledge of the subject and shows plainly that the height of reinforced concrete buildings should not be arbitrarily limited, but be governed as steel buildings are, by the size and strength of the members. It also has chapters on the relative resistance to fire of cement, stone and brick buildings, showing the advantages of the former; on sewer pipe, showing the superiority of cement pipe; on cement street paving and cement shingles. It is well printed and illustrated.

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Reinforced Concrete in the Proposed New Building Code of New York City.

Building codes are born to trouble. After three years' deliberation an aldermanic committee has completed a new building code for the cities of Greater New York. Its chief success seems to have been in arousing criticism. Not only have nearly every technical organization and many individual engineers passed criticism, but the committee who drafted the document is divided in opinion, and one faction condemns what another faction approves. So far as reports indicate this criticism is directed pretty generally to all of the engineering features of the code. Particular attack, however, is made on those portions relating to reinforced concrete construction and from the printed reports of a public hearing which has just come to hand we judge that this attack is entirely warranted. We do not propose here to specify even the obvious faults of detail but the general criticism of reinforced concrete as a building material which the code implies does call for mention.

Briefly, while all other building materials are unlimited as to use in buildings of any height desired the use of reinforced concrete is limited to buildings 75 ft. in height. This is the figure of the majority report of the aldermanic committee; the minority report increases the limit to 85 ft. Just why these particular heights were assumed to be the proper limits we do not know and we anticipate that the committeemen who signed the reports would be puzzled to tell. But regardless of this detail why should any limit of height be put on reinforced concrete buildings? We can understand and can even find a measure of approval for a law restricting the height of all city buildings but no distinction should be made in this law between concrete and any other building material. New York City has concrete buildings over 85 ft. high and they are doing their work safely and well, so that the aldermanic committee did not even have to go from home to find an indication at least that their height restriction was foolish. But there is small sense in quoting evidence of this sort or of any sort to show that reinforced concrete is a safe material with which to build to any height which the limitations set by good design and commercial considerations will allow.

Reinforced concrete structures, that is structures whose framework or shells are reinforced concrete will not, except in very rare cases, be attempted beyond certain heights. After a height of [illegible] twelve stories is reached reinforced columns become so bulky that commercial considerations will compel engineers and builders to resort to a [illegible] structure. No building code should do more than fix safe allowable stresses and [illegible] permissible [illegible] with [illegible] of bearing qualities of materials, etc., for reinforced concrete building work. In a word it should be governed on the same basis that steel construction is governed and on no other basis.

It is a curious fact that concrete has had to fight its way in New York City from its very first attempt at building work as a material for fireproof floor construction. Not a few of our readers will recall the struggle that took place 12 or 15 years ago when the concrete fireproofing and [illegible] fireproofing interests locked horns over possession of the fireproof field of New York City fireproofing work. It was this struggle that developed the New York Building Department standard fire test, which afterward became common in many other cities. Concrete had proved its right to be considered a safe material for fireproof floor construction and came to a [illegible] in this field [illegible] served only to [illegible].

There is a similar fight now before reinforced concrete interests and from the reports presented so far we cannot help feeling that they have gone about it [illegible] in a weak way. So far only the most general criticism has been presented and criticism that is wholly destructive. No one has so far as we know come before the aldermanic committee with a definite set of substitute rules or of amendments [illegible]. It is not enough to say that a particular rule is bad; the critic should not only [illegible], but should offer a better rule. This has not been done and [illegible] has not escaped the committeemen who have been [illegible]. In the printed report of the first hearing which is before us we find evidence of this [illegible] of one of the committee as follows:

> It would be a great help to the committee if the gentlemen who make objections to the various sections of the proposed code would state specifically the matter of objection and by stating an amendment what they want inserted in the [illegible] of words, and so in their judgment [illegible] to the committee which [illegible]. To simply state that something is [illegible] against your interest does not [illegible] how to correct it [illegible].

A committee of the American Society of Civil Engineers has been appointed within the last week to protest against the provisions of the proposed New York building code. [illegible] the opportunity of this committee to do really useful work lies in showing just what the [illegible] reinforced concrete should be. Any general protest will [illegible].

The [illegible] Tunnel of the [illegible] Valley Project of the U. S. Reclamation Service [illegible] May [illegible] in the east heading and [illegible] in the west heading, leaving [illegible] between the headings at the end of the month. The material encountered in both headings has been granite. Timbering has been necessary in the west heading. Concrete lining has been placed during the month [illegible]. The [illegible] pumping from the west portal has averaged 53 second feet and that pumped from the east heading has averaged 175 second feet.

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Concrete and Reinforced Concrete Section

Note:—This section is devoted to methods and cost of constructing concrete and reinforced concrete structures. It will cover the selection, testing and proportioning of concrete materials; laboratory tests of concrete; concrete mixing, transportation and placing; fabrication and placing of reinforcement, and form construction and erection. It will also contain articles on new and interesting developments in the design of reinforced concrete.

A Concrete Mixing and Handling Plant for Constructing a Dam With Some Details of Cofferdam Work.

Unusual efficiency in mixing and handling concrete for a large dam was obtained by the plant arrangement illustrated and described here. The dam was built to cross the Connecticut River between Vermont and New Hampshire at Billows Falls, Vt., and it contained 5,250 cu. yds. of rubble concrete. It replaced an old timber dam. This old dam in order to take advantage of outcropping ledges had a zig-zag course across the river; there were five bends in the line. The new dam was built just below the old dam, its vertical back close to the front face of the cribwork of the old dam after removal of the apron, as shown by Fig. 1.

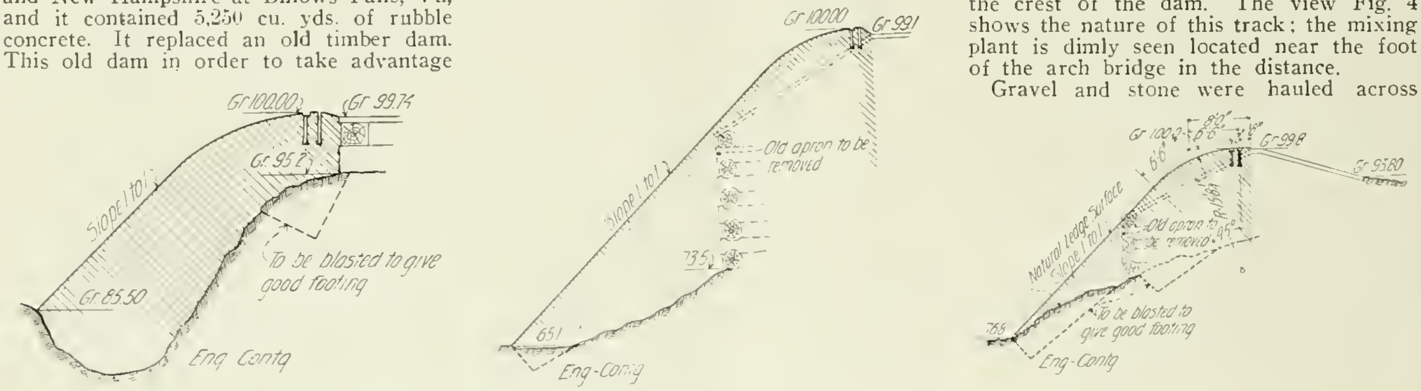


Fig. 1. Typical Sections of Bellows Falls Concrete Dam.

The alinement of the new dam is indicated on Fig. 2. Measured along the crest its total length is 563.2 ft. Its greatest height is 38 ft. It is built of 1-3-5 concrete with not exceeding 30 per cent of rubble stones. The aggregate for the concrete was reduced to a size such that at least 80 per cent passed a 2-in. ring. The rubble stones were at least 1 cu. ft. in volume. A clearance of 8 ins. was required for all embedded rubble. The dam was designed by Charles T. Main of Boston, Mass., and the Aberthaw Construction Co., of Boston, was the contractor.

The general lay-out of the work is shown by Fig. 2. The conditions were these. The deepest water was near the Vermont shore and the depth grew shallow at the New Hampshire shore. The Vermont shore was not available for contractor's plant but there was plenty of room on the New Hampshire shore. On the Vermont shore about 50 yards from the bridge there was a gravel bank and about ¼-mile away, a quarry. Stone could also be had from excavation for footings necessary on the Vermont side. About 50 yards upstream from the dam a highway bridge crossed the river with its floor some 26 ft. higher than the crest of the dam. Briefly, then, the bulk of the materials required for concrete making were located on the Vermont shore while the plant had to be located on the New Hampshire shore.

Two plans for handling the work were considered besides the one adopted. One was a cableway plant. This offered freedom from damage by flood, but owing to the zig-zag course of the dam did not appear to "cover" the work so well or to be of such general utility as the plan adopted. A second plan consisted in maintaining the mixer plant on a large pontoon and of supplying this with smaller pontoons. By mounting the mixer high on the pontoon it might have been possible to run the concrete directly into the forms, but the expense of hoisting the materials, slowness of operation and cost of pontoons seemed to make this plan less desirable than the one adopted. Briefly the adopted plan was to build a stationary mixing plant (Fig. 3) on the New Hampshire shore and to carry a dump car track from it on a trestle directly over and following the crest of the dam. The view Fig. 4 shows the nature of this track; the mixing plant is dimly seen located near the foot of the arch bridge in the distance.

Gravel and stone were hauled across the bridge to the mixer plant from the gravel pit and quarry on the Vermont shore. The gravel was excavated by an orange peel bucket and dropped onto a screen at the top of elevated bins with hopper bottoms. The screens separated the pebbles from the sand and the materials were separately chuted direct from the bins into wagons. A ½-cu. yd. orange peel bucket was used, operated by a derrick, with a 40-foot mast and a 70-ft. boom and having a 7x9-in. engine.

The mixer plant was the framed struc-

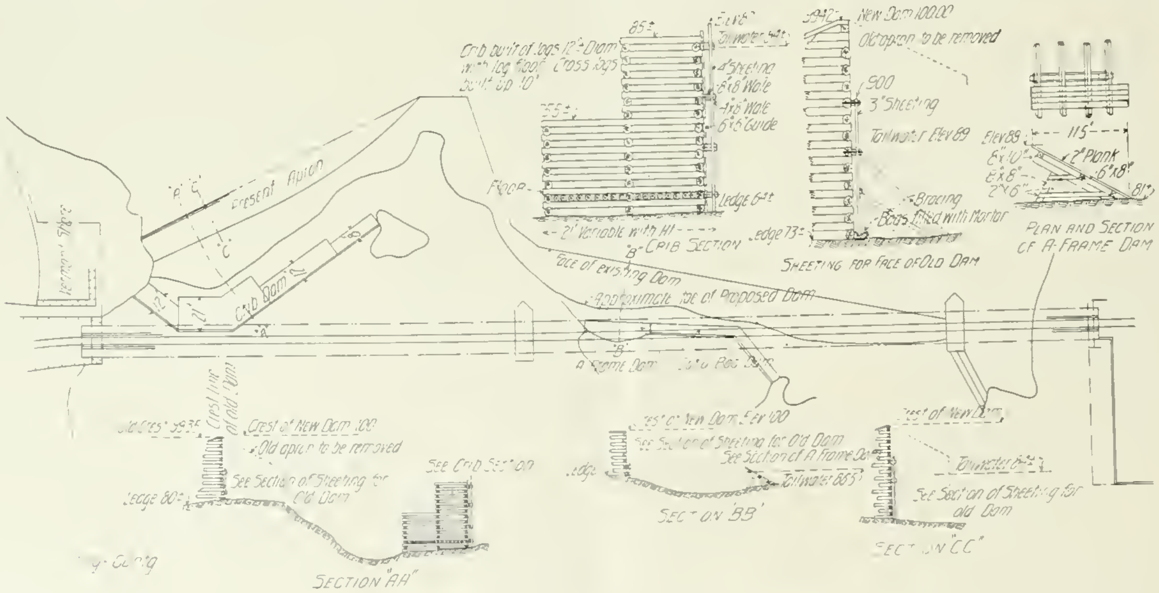


Fig. 2. Plan of Bellows Falls Dam Work With Cofferdam Details.

ture shown in plan and elevation by Fig. 3. The wagons coming with sand, gravel and stone drove onto the platform and dumped their loads onto the inclined chutes. Stone and gravel were washed. A perforated pipe fed by a centrifugal pump sprayed water over the gravel and stone and washed out the dirt and fine material which passed through the screens shown and were carried away through the dirty water chute, while the coarse material passed into the bins. Gates at the bottoms of the bins connected with chutes for delivering the materials as wanted. The chutes from the sand and gravel bins fed into measuring hoppers or compartments which discharged directly into the charging hopper of the mixer. Bags of cement were chuted to the charging platform direct from the cement house [illegible]. The course of the cement chute is clearly shown by Fig. 3. The mixer was a 21 cu. ft. batch Smith mixer and it discharged directly into Koppel cars on the track below. A 35 h. p. electric motor supplied power for the plant. This motor, operating at 900 r. p. m., operated a countershaft at 360 r. p. m., which turned the batch mixer and centrifugal pump, the former turning 12 r. p. m. and the latter 510 r. p. m.

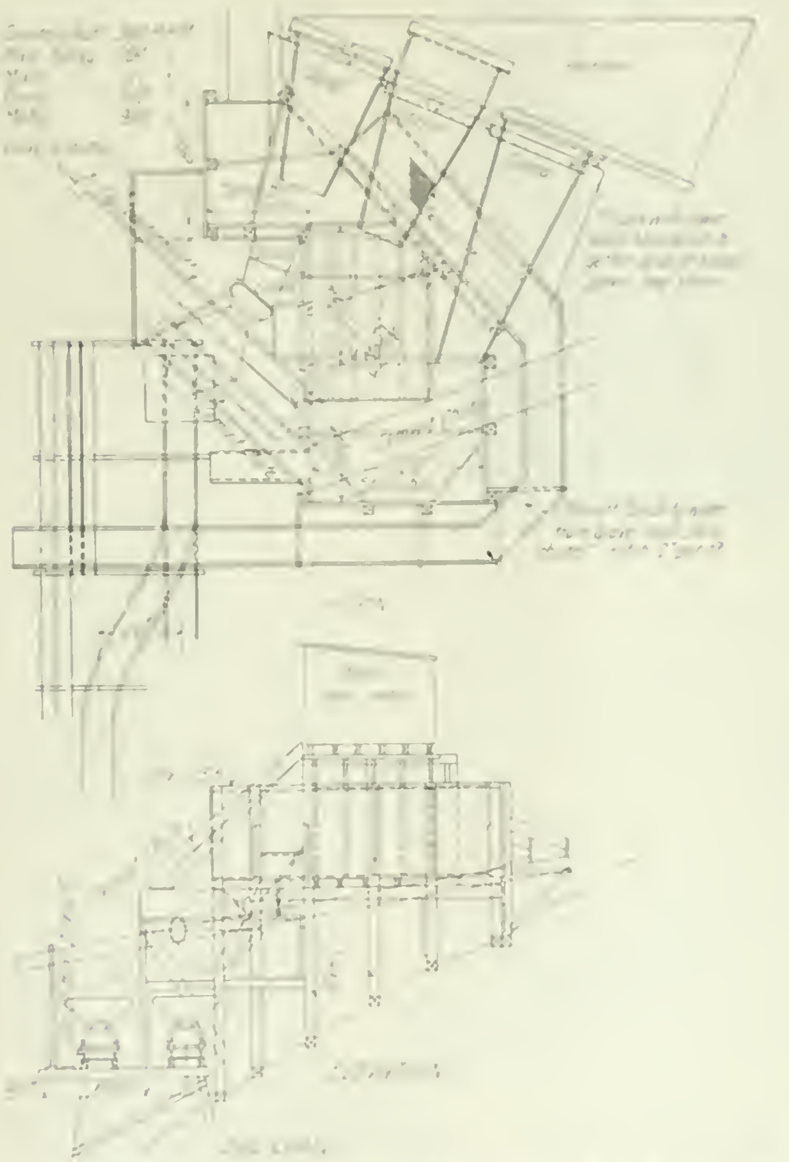


Fig. 3. Plan and Elevation of Concrete Mixing Plants Bellows Falls Dam.

The dump car tracks under the mixer were 24-in. gage and were carried the full length of the dam on a timber trestle directly above and about 4 ft. higher. This track was level its full length and had sidings to allow cars to pass. A branch track was extended ashore to a lumber yard and [illegible] shop and this track along the dam therefore handled all construction materials, supplies and machinery as well as concrete and in addition provided a bridge for workmen. The route of the track is plainly indicated by Fig. 1. The dump cars handling concrete held 21 cu. ft., one batch, and were propelled by hand, two men to a car. At [illegible] as shown by Fig. 1.

Reviewing the arrangement for the concrete work it will be noted that gravity handling of [illegible] was employed. [illegible]

[illegible]

Total [illegible]

[illegible]

Construction was begun at the New Hampshire end of the dam and was [illegible]. The new concrete dam was built close against this cribwork as indicated by the sections, Fig. 2. The old dam thus served largely as forms for the upstream face. It also served as an upstream cofferdam wall. To fit it better for this purpose, sheeting of [illegible] was driven close to the cribwork as shown by one of the drawings of Fig. 2. In addition [illegible] 4 to 6 ft. high was erected along the crest of the old dam. The downstream cofferdam wall had to be built new as did the bulkhead walls between upstream and downstream dams. This downstream dam varied in character according to the depth of the water. In shallow water the simple triangular section shown by one of the drawings of Fig. 2 was used and in places merely a dam of sand bags sufficed. In deep water a cribwork dam was constructed as shown by Fig. 2. The cribs were built as rafts, floated to place and sunk by stone filling and then sheeted on the upstream side. Generally 12-in. logs were used for the cribs. After construction the stone was removed from these cribs and they were dismantled. All the work described was done in sections terminated by cross bulkheads, the portion of the dam within each section being built separately.

The forms for the downstream part of the dam shown by Fig. 1 were [illegible] sheeting and were [illegible]. The bottoms of the [illegible] were held by wiring them to steel pins driven into the ledge rock.

The total cost of the dam [illegible]

[illegible] Concrete Pavement.—[illegible] Washington, D. C., [illegible]

[illegible]—[illegible] in connection with the construction of the [illegible] way at Philadelphia, Pa., [illegible] a vertical steam boiler of 10 to 12 HP. for the purpose of heating the water, sand and stone. A 2-in. pipe with cross arms of 1-in. pipe at right angles to it, pierced with ⅛-in. holes and connected with the boiler by a short length of steam hose, served to supply sufficient heat to prevent freezing by blowing live steam into the sand and stone. A permanent 1-in. connection was taken off the boiler and turned down into the water barrel which was mounted on a platform back of the concrete machine, and served to heat the water used in mixing the concrete. No precautions were taken to prevent freezing of the concrete, other than covering it with salt hay after it had been placed. Concrete was placed when the temperature at the street surface was as low as 15° F. and no bad effects due to freezing of the concrete are noticeable.

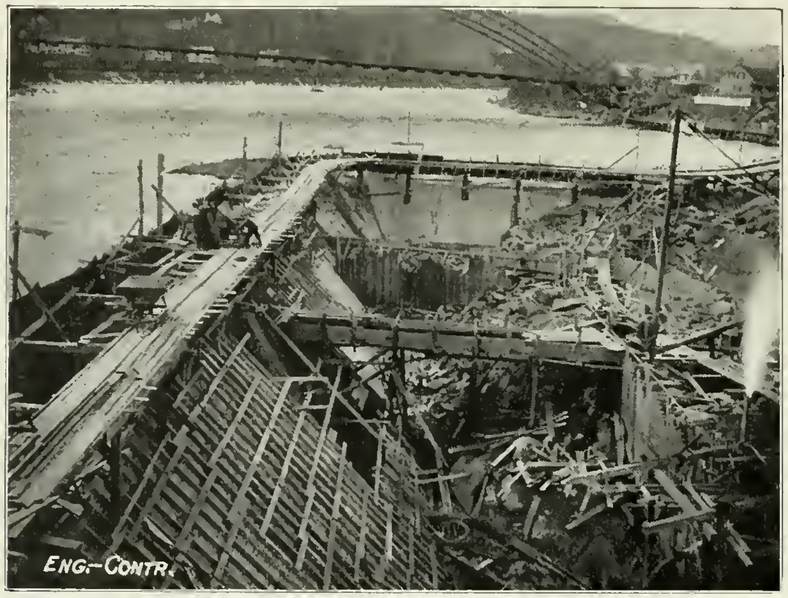


Fig. 4. View of Bellows Falls Dam Work Showing Forms and Service Railways.

Unit Cost of Pipe Sewers at Washington, D. C.—The following table, taken from the report of the Engineer Department of the District of Columbia for the year ending June 30, 1908, shows the average cost per linear foot of pipe sewers constructed by day labor during the fiscal year:

Size of Sewer.	Length.	Cost of materials.	Cost of labor.	Total cost.
	Ft.	Lin. ft.	Lin. ft.	Lin. ft.
8-in.	949	$ 0.422	$ 1.343	$ 1.765
10-in.	12,657	.498—	1.262	1.76
12-in.	20,347	.61	1.44	2.05
15-in.	5,118	.752+	1.69	2.442
18-in.	3,058	.90 +	1.906	2.806
21-in.	851	1.139	1.737	2.876
24-in.	517	1.504—	3.648	5.252
10-in. connection ...	1,098	.498	.631	1.129
12-in. connection ...	3,055	.61	.72	1.33
15-in. connection ...	198	.752	.845	1.59
18-in. connection ...	131	.90	.953	1.853
Catch-basins	186	17.66	26.787	44.447

In the table it is assumed that the cost of materials used in basin construction is the same as that in the same size sewer. It is also assumed that on account of the difference in depth of excavation the cost of labor for catch basins is half the cost of that of the same size sewer. The table does not include cost of work of exceptionally difficult construction.

A New Form of Beam Reinforcement Using Expanded Metal Stirrups.

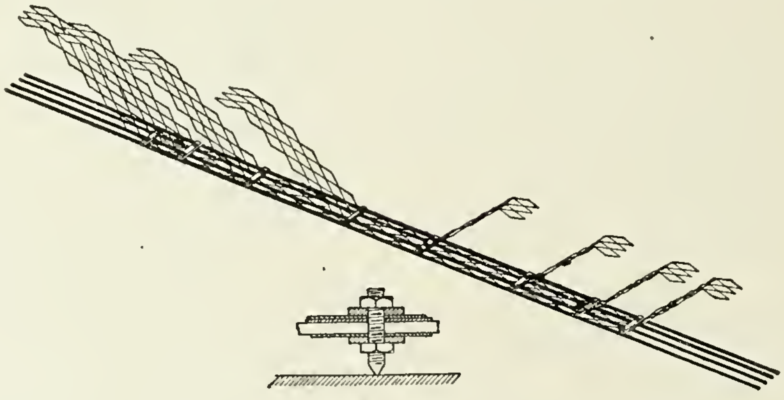
The accompanying illustrations show a new beam reinforcement designed by Mr. Ernest McCullough, C. E., and now being made by the Northwestern Expanded Metal Co., of Chicago, Ill. This reinforcing unit has been designed with the matter of web reinforcement particularly in mind, and it is believed to satisfy all requirements.

The claims made are specified as follows by the inventor:

(1) The web reinforcement is rigidly attached to the horizontal tension steel.

2. The web reinforcement is so arranged in the beam that it is a part of the horizontal tension steel.

(3) The web of expanded metal mesh that takes the place of stirrups ordinarily used, can be so arranged that the spacing between the webs can be of any desired amount.



Unit Reinforcing Frame with Expanded Metal Stirrups.

(4) The web reinforcement after going through the beam diagonally, or vertically as the designer may desire, is bent over near the top of the beam so that it is thoroughly tied into the concrete that is in compression.

(5) The method of holding the layers of expanded metal together and of attaching them to the horizontal steel rods or bars is capable of almost any adjustment desired and the bolts that run through can be so adjusted as to hold the steel above the bottom of the form at any required distance.

The company's method of designing a beam involving the use of this web reinforcement is to determine the amount of steel required for tension in the bottom, in the middle of the beam. Then determine the number of stirrups that would be used on one-half the beam and use this number of layers of expanded metal. The sum of the areas of the layers of expanded metal being subtracted from the total amount of steel required in the middle of the beam, gives the amount of steel required to be furnished in the form of rods or bars. These rods or bars are then put in place and the beam is fabricated.

Methods of Constructing Concrete Silos with Some Data on Design.

I.

Silo construction provides one of the most valuable of the many uses for concrete on the farm. The advantages of concrete over wood are: It is not rotted by the acid and moisture of the silage; it is vermin proof, and it costs very little to maintain and repair. Concrete silo construction is usually conducted by small local contractors or by the farmer himself; both usually have small knowledge of concrete. This article, therefore, goes more minutely into details of construction than would be essential were it written for experienced concrete designers and builders. It has been prepared from several recently published articles* and from miscellaneous data collected by the editors.

TYPES OF CONCRETE SILOS.

Three types of concrete silos are employed: (1) Solid wall monolithic concrete; (2) hollow wall monolithic concrete, and (3) concrete block. All three types have given successful results. Choice between them is decided by relative local cost and by the extent which it is deemed necessary to guard against frost.

Cost.—Local conditions affect materially the relative costs of the three types of construction specified. Generally, hollow wall monolithic construction will cost 25 per cent more than solid wall monolithic construction; as between concrete block construction and hollow wall monolithic construction, economy is sometimes in favor of one and sometimes in favor of the other. Some examples of cost of concrete silo construction are given in a succeeding section. In planning to build a concrete silo the only way to decide which type of structure will be the cheapest is either (1) secure comparative bids from local contractors, or (2) make comparative estimates based on local prices of materials and rates of wages.

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*C. W. Gaylord and Percy H. Wilson, in Bulletin 21, Association of American Portland Cement Manufacturers; M. L. King, in Proceedings Fifth Annual Convention, Iowa Association of Cement Users; Walter B. Phillips, in "The Cement Record," May, 1909.

Frost Proof Qualities.—Both hollow block construction and hollow wall monolithic construction are superior in frost proof qualities to solid wall monolithic construction. Hollow wall construction practically eliminates freezing of silage. A solid wall construction probably gives as certain protection against freezing as does wood silos as ordinarily constructed. The necessity of guarding against freezing is a question (1) of climatic conditions and (2) of convenience and cost. It takes a considerable period of cold weather to freeze silage. Freezing does not, it is generally considered, injure the silage itself and if it is thawed out before feeding the freezing causes no injury to the stock eating it. The question is then whether the cost in labor and time of thawing frozen silage is great enough to warrant a more expensive silo construction to prevent freezing. This answer of course depends upon the duration of the freezing weather, the relative cost of the two types of construction, and the expense of thawing.

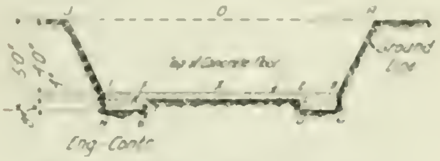

Fig. 1. Sketch of Silo Foundation.

SIZE AND CAPACITY OF SILOS.

The size and capacity of silo required will depend upon the number of cattle to be fed and the duration of the period for feeding silage. Gaylord and Wilson advance the theorem that the number of animals to be fed should determine the diameter of the silo and the length of time that silage is wanted should determine the height. They assert, however, that the inside diameter should never be more than one-half the height and in practice it is not found advisable to make the diameter over 20 ft. To determine the size decide first what amount of silage is to be fed each animal per day, then make the diameter such that this ration multiplied by the number of animals fed will aggregate an amount which will reduce the depth of the silage at least 2 ins. per day; this rate of removing the silage will prevent molding. An average ration is 40 lbs. per day per animal. It is well to keep the silo small enough in diameter to permit this ration to be cut down one-half and still have the silage lowered fast enough to prevent molding. This can be accomplished by constructing two small silos instead of one large one, and it is coming to be common practice to do so.

Table III.—Giving Dimensions for Laying Out Foundations of the Form Shown in Fig. 1. Length of Lines.

Diameter of silo in feet	For hard or firm ground O-A Ft.	In.	X-D Ft.	In.	X-E Ft.	In.	E-B Ft.	In.	B-C Ft.	In.	For medium ground O-A Ft.	In.	X-D Ft.	In.	X-E Ft.	In.	E-B Ft.	In.	B-C Ft.	In.
10	8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2	[illegible]	1	[illegible]	8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1	6
11	8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1	6
12	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1	6
13	[illegible]	9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1	[illegible]	10	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1	6
14	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1	[illegible]
15	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1	[illegible]
16	11	3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1	[illegible]
17	11	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1	[illegible]	12	[illegible]	10	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1	6
18	12	3	10	3	[illegible]	[illegible]	2	[illegible]	1	[illegible]	[illegible]	[illegible]	10	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1	[illegible]
19	12	[illegible]	10	[illegible]	[illegible]	[illegible]	2	[illegible]	1	[illegible]	[illegible]	[illegible]	11	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1	[illegible]
20	13	[illegible]	11	[illegible]	[illegible]	[illegible]	2	[illegible]	1	[illegible]	13	[illegible]	11	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1	[illegible]

Note.—In a stiff firm clay O-A can be made 1 ft. shorter than shown and in sandy or soft ground it may have to be made a foot or two longer.

Table I.—Giving the number of cows in herd and tonnage of silage for both 180 and 240 days of feeding of 40 lbs. of silage per cow; also acreage of corn estimated to fill the silo and the dimensions of the silo itself. The diameters given are such that at least 2 ins. in depth of silage will be taken off daily.

Number of cows in herd	Feed for 180 days Estimated tonnage of silage consumed Tons.	Size of silo Diameter Feet	Height Feet	Corn required acreage at 15 tons to acre Acres	Feed for 240 days Estimated tonnage of silage consumed Tons.	Size of silo Diameter Feet	Height Feet	Corn acreage required at 15 tons to acre Acres
10	36	10	27	2½	48	10	31	3½
12	43	10	28	3	57	[illegible]	[illegible]	4
15	54	11	[illegible]	4	72	11	36	[illegible]
20	72	12	[illegible]	5	96	[illegible]	[illegible]	6½
25	90	13	[illegible]	6	120	13	[illegible]	8
30	108	14	34	7½	144	15	[illegible]	[illegible]
35	126	15	34	8½	168	16	[illegible]	11
40	141	16	35	[illegible]	192	17	[illegible]	17
45	162	16	37	11	216	18	[illegible]	11½
50	180	17	37	12	240	19	[illegible]	16
60	216	18	39	11½	288	20	[illegible]	19
70	252	19	40	17	336			

Table II.—The Approximate Capacity in Tons of Round Silos.

(The diameter is shown at the top of the columns and depth at the left.)

Height of silo Feet.	Inside diameter of silo in feet and the capacity in tons (2,000 lbs.) 10 ft. Tons.	11 ft. Tons.	12 ft. Tons.	13 ft. Tons.	14 ft. Tons.	15 ft. Tons.	16 ft. Tons.	17 ft. Tons.	18 ft. Tons.	19 ft. Tons.	20 ft. Tons.
20	26										
21	28										
22	30	36									
23	32	39									
24	34	41	[illegible]								
25	36	43	52								
26	38	46	[illegible]	64							
27	40	49	[illegible]	68							
28	42	51	61	71	[illegible]						
29	44	54	64	[illegible]	87						
30	47	56	67	[illegible]	91	[illegible]					
31	49	59	70	83	96	[illegible]					
32	51	62	74	[illegible]	[illegible]	[illegible]	[illegible]				
33	53	65	77	[illegible]	[illegible]	[illegible]	[illegible]				
34	56	68	80	94	[illegible]	[illegible]	[illegible]	[illegible]			
35	58	70	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			
36	61	73	87	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		
37	63	76	90	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		
38	66	79	94	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
39	68	82	97	115	133	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
40	70	85	101	119	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Tables I and II are given by Gaylord and Wilson [illegible] in determining [illegible] and capacity of silos.

SILO CONSTRUCTION.

Silo construction [illegible] the following [illegible]: (1) Foundation Construction, (2) Wall Construction [illegible] forms [illegible], (3) reinforcing and (4) concreting, (5) Roof Construction, (6) Door, Window and Ladder Construction. The [illegible] will be considered under these divisions and appropriate [illegible].

FOUNDATION CONSTRUCTION.

The weight of a concrete silo, including contents when full will seldom exceed 2 tons per square foot of foundation area. Any good, firm soil will carry this load. Construction, therefore, ordinarily consists merely of excavating to well below frost line and to firm material and providing a footing or bottom which will distribute the load evenly. Where ordinarily good foundation soil cannot be found, which is rare, special methods of construction will have to be determined upon and for the specific regarding such foundations the builder should consult the standard engineering treatises or call in an engineer to prepare a design. The foundation designs given here are such as are ordinarily employed and are sufficient in nearly all cases where silos are likely to be built.

Excavating Foundation Pit.—The depth of foundation pit required merely to obtain firm ground will seldom exceed 7 ft.; probably 5 ft. is a fair average. The pit should be excavated with sloping sides flat enough to prevent caving and with a bottom diameter somewhat greater than the outside diameter of the silo. The above remarks refer of course only to silos which may be considered essentially wholly above-ground structures. In some instances silos are designed to be partly below ground. As an illustration two silos constructed [illegible] are 14½ ft. and 17 ft. in diameter respectively and [illegible] ft. high, of which [illegible] ft. are below ground level. Excavating foundation pits of this depth call for more [illegible] methods and equipment and some [illegible] bracing of some character.

Example I.—Figure 1 shows a good example of foundation given by Messrs. Gaylord and Wilson. To lay out a foundation of the form [illegible] as follows: Drive a stake at O, the center of the site to be occupied by the silo and with a string of a length equal to O-A mark a circle on the ground. To find the proper length of O-A look in Table III opposite the diameter of silo it is planned to build. Next excavate the pit A B C D and [illegible] the bottom of the center over the stake O and with a cord of a length equal to X-D mark a cir-

Fig. 2. Sketch of Silo Foundation

cle, then shorten the cord to a length equal to *X E* and mark a second circle. The proper lengths of cord *X B* and *X E* will be found in Table III opposite the diameter of silo it is planned to build. Next excavate the trench *E B D C* entirely around the pit. Table III shows the depths *B C* and the widths E B of this trench for different diameters of silo. If the ground is so soft that the sides of the trench will not stand alone support them by short lengths of boards on edge and held by stakes. Next cut down the floor of the pit within the circle of the trench enough to make the side *L D* 4 ins. less than the side *B C;* this gives a 4-in. concrete floor when the trench is filled the full depth *B C* with concrete. Use a medium wet 1-3-6 mixture and tamp it well; smooth off the top between *F* and *E* as this will be the floor of the silo.

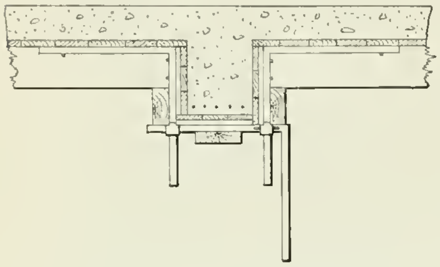

Fig. 1. Clamp Applied to Interior Girder Form.

Example II.—Where the ground is soft construct the foundation as in example I, except that it should be reinforced as follows: After covering the bottom of the trench about 4 ins. deep with concrete place reinforcing bars or wires upon the concrete. These bars or wires should be bent into circles reaching entirely around the trench. The first circle should be placed about 3 ins. from the outside face of the trench; the second circle 6 ins. inside the first, the third circle 6 ins. inside the second and so on for the full width of the trench. On these circles lay short rods reaching across the trench; the outer ends of these rods should be 12 ins. apart and the direction of the rods should point to the center *X*. When the reinforcement has been placed continue the filling of the trench with concrete.

Example III.—The following directions for constructing a foundation for a 10-ft. silo are given by W. B. Phillips, C. E.: Excavate a circular pit 13 ft. 8 ins. in diameter and make the bottom smooth and level. Place a 4-in. layer of 1-2-4 concrete over the whole bottom. On this lay two 8x12-ft. sheets of expanded metal crossing each other at right angles at the center of the foundation; elevate the expanded metal sheets at the center as shown at *A* Fig. 2 and block them up with stones. Place 8 ins. of concrete embedding the expanded metal. Next cut a sheet of expanded metal lengthwise into three strips and connect these strips end to end to form a ring 10 ft. 10 ins. in diameter; set this ring, *E E*, on edge on the concrete footing and concentric with the walls of the silo. Finally complete the concreting of the footing to the ground level. In connecting up the strips of expanded metal to form the ring *E-E*, lap the ends and wire them firmly together; use a No. 10 gage 3-in. mesh expanded metal throughout. While the drawing, Fig. 2, shows a foundation only 2 ft. below ground, it is plain that this same footing can be constructed in as much deeper a pit as conditions necessitate.

Example IV.—Excavate a pit to the necessary depth and diameter and within it construct a circular footing wall to the ground surface. This wall will require circular forms of one of the styles described later. Fill inside the footing wall with cinders, gravel or broken stone placed in layers and tamped hard. Fetch this filling up to within 8 ins. of the top of the wall. Roughen the inside of the wall above the filling by picking with a stone axe and wash down the picked surface. Fill inside the wall with concrete to within 1 in. of its top. This concrete should be tamped into close contact with the picked surface; a 1-2½-3 concrete mixture will serve for both wall and floor. This construction was employed for a 200-ton silo at White Plains, N. Y.

General Suggestions.—The foundation bed of earth on which the concrete is placed should be dry and firm. If rain entering the pit makes mud it should be removed and if there is much ground water fill in a few inches with gravel, pebbles or crushed stone before placing the concrete. The concrete footing should, if possible, be placed continuously until it is finished. To this end see that all materials for the concrete are on hand and that the reinforcement is cut and made ready to put in place rapidly so that it can be got into place and concreting be resumed before the concrete previously placed has begun to set.

An Adjustable Metal Clamp for Concrete Forms.

One of the most annoying problems of form construction for concrete work is the problem of devising fastenings or frames for holding the forms together. Such fastenings to be wholly satisfactory must satisfy a number of requirements. They must fasten and hold the parts together rigidly and maintain their position under loading; they must "save" the form lumber; they must be quick and easy to place and remove, and they must be adapted to variations in size of concrete members. A great many forms of clamps and form holders have been devised but none of them has met with general favor and most builders still employ wooden yokes, cleats, braces, etc., for fastenings, while waiting for a more perfect and economical means to be devised.

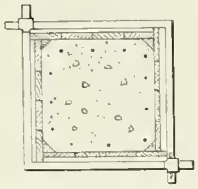

Fig. 2. Clamp Applied to Column Form.

The accompanying illustrations show a late invention which has been offered for consideration. It is an adjustable metal clamp adapted to fasten both column forms and girder boxes. The clamp is made in two parts shaped like a carpenter's square and of two or more locks through which the arms of the "square" slip and can be held tight together by wedge keys. The construction is simple. Figures 1, 2 and 3 show the clamp applied to a column form and to a wall girder form and an interior girder form, respectively. The operation of placing and removing the clamps are simple and can be performed safely by any workman and absolutely no cutting of the form lumber is required for either operation. This clamp is made by the Interlocking Concrete Steel Co., of Cleveland, O., in standard sizes of 2½ ft. over all of ½x1¼-in. steel and are sold for $3 per set.

Papers in Engineesing Education, and on Concrete.

The following papers and reports on engineering education are to be presented at the annual meeting on June 24-26 in New York City of the Society for the Promotion of Engineering Education: "Highway Engineering," by L. W. Page; "The Relation of Engineering Education to Industries," by Mr. Charles Buxton Going, editor Engineering Magazine; "Efficiency in Education," by Professor George F. Swain, Massachusetts Institute of Technology; "The Extension Work of the University of Wisconsin," by Professor Louis E. Reber, University of Wisconsin; "Report of the Joint Committee on Engineering Education," by Professor Dugald C. Jackson, chairman; "The Five Year Courses," by Professor Charles Derleth, Jr., University of California; "The Five and Six Year Courses in Engineering Schools," by Professor Robert Fletcher, Dartmouth College; "The Five Year Courses," by Professor William T. Magruder, Ohio State University; "Employer's Requisites of Technical Graduates," by Professor Hugo Diemer, The Pennsylvania State College; "Report of Committee on Graduation," by Professor John J. Flather, chairman; "Outlines of the New Course in Elementary Physics," by Professor William S. Fraanklin, Lehigh University; "A Summer School in Surveying," by Professor Charles Derleth, Jr., University of California; "Careers of Graduates of the University of Michigan," by Dean Mortimer E. Cooley, University of Michigan; "The Requisite Qualifications of an Engineering College Instructor," by Mr. Oliver B. Zimmerman, Charles City, Ia.

The following papers relating to cements and concrete will be presented at the annual convention on June 26-29, at Atlantic City, N. J., of the American Society for Testing Materials: "Standard Specifications for Cement" report by committee; "Tests of Plain and Reinforced Concrete Columns" by M. O. Withey; "Suggestions as to the Practical Use to be Made of Cement Testing," by Richard K. Meade; "Further Tests of Reinforced Concrete Beams Under Oft-Repeated Loads," by H. C. Berry; "Tests of Bind of Steel Rods Imbedded in Concrete by Three Methods," by H. C. Berry; "Concrete Reinforced by Nails," by L. S. Moisseiff.

The census of western Canada, announced recently, shows a population of 1,100,000. Of this number 500,000 live in Manitoba, 350,000 in Saskatchewan and 275,000 in Alberta. This is an increase of 300,000 in three years.

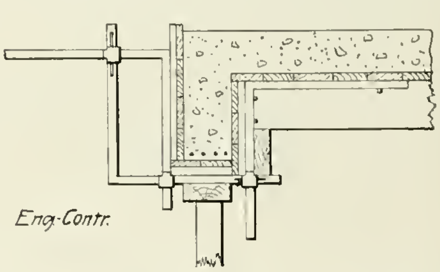

Fig. 3. Clamp Applied to Wall Girder Form.

During the month of May 16,300 cu. yds. of masonry were laid in the Roosevelt Dam up the Arizona, Salt River Project of the U. S. Reclamation Service. The dam at the end of the month was 78 per cent completed.

Earth and Rock Section

Note: This Section is devoted to methods and costs of excavating earth and rock and building embankments. It will cover the grading of roads and railroads, diking and canal work, dredging, building reservoirs and earth dams, sewer and water pipe trenching, quarrying, etc.

Comments on the Excavation of Trenches and Ditches.

(Continued from June 16 issue.)

A decade ago nearly all trenches and most small ditches were dug by hand, that is with picks and shovels. Today we have many tools, machines and appliances that are meant either to excavate trenches and ditches or to assist in their excavation. In spite of this there will always be ditches and trenches dug by hand, for it is evident that many small jobs will not stand the cost of installing expensive outfits and that some work is not suited to trench excavating machinery. However, in ditch work, machinery will be used more and more, and on any extensive job of trenching or ditching it will generally be found economical to use it.

These machines can be divided into three classes, namely, trench digging machines, ditch digging machines and trenching machines. It is a fact that some trench digging machines will also excavate ditches and vice versa, but the manufacturers also make this distinction, and it is well for contractors to understand that there is a difference. For instance, a machine that is of the same type and pattern is built much heavier and stronger for trench excavation than for ditch work. The one for ditch work may be called a [illegible], while the one meant for trench work may be called a contractor's machine, indicating that it is meant for heavier work. Thus a ditcher that is put to digging large trenches in hard material may not stand up under the work. Trenching machines are not meant to be excavating machines, but are designed to handle the excavated material, to back fill the trench, and also handle other materials that may be used in the trench.

The simplest tool, aside from the pick and shovel, with which a trench or ditch can be excavated, is a scraper. For shallow trenches and ditches a drag scraper is used. Shallow trenches can be excavated entirely, excepting the trimming up, with a drag scraper. But for deep trenches where a long run has to be made to maintain the grade, or a very steep grade has to be ascended with the load, this naturally makes an economic limit for this work. The writer has used drag scrapers for trenching and has found [illegible] many trenches could be excavated cheaply by first excavating from 4 to 6 ft. wide [illegible], making a slope on the sides of the trench. This slightly increases the yardage, but the scraper work with a short run is done at a low cost and by dumping the [illegible] on the banks, [illegible] distance, which is an important item, especially when [illegible] is used.

For wide trenches and ditches Fresno or drag scrapers may be used for the same purpose as the drag, but the trench must be at least 4 ft. wide, and only [illegible] should be used in the scraper, unless the trench is 6 ft. or more in width.

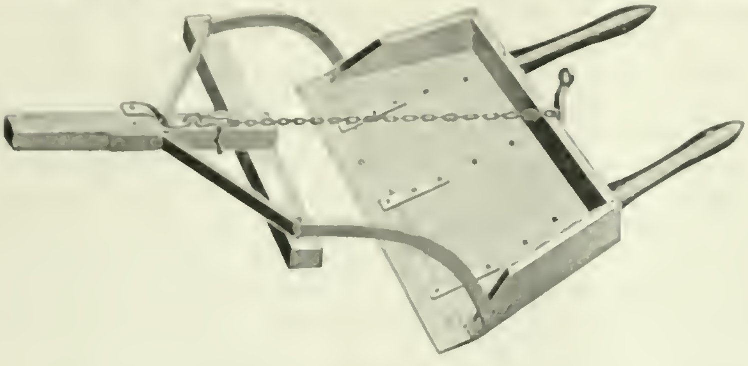

Fig. 1. Tongue Scraper.

In Fig. 1 we show a drag scraper called a tongue scraper. This scraper is made of wood faced with metal and derives its name from the fact that a tongue is used in it, while with other drag scrapers a tongue is not needed. The tongue scraper is operated in a manner similar to a drag, and although it can be used in a trench to considerable advantage at any time, [illegible] the best tools in cleaning ditches, and is an excellent tool for cleaning out trenches. Drag scrapers, Fresnos and tongue scrapers are made by all the companies that manufacture scrapers.

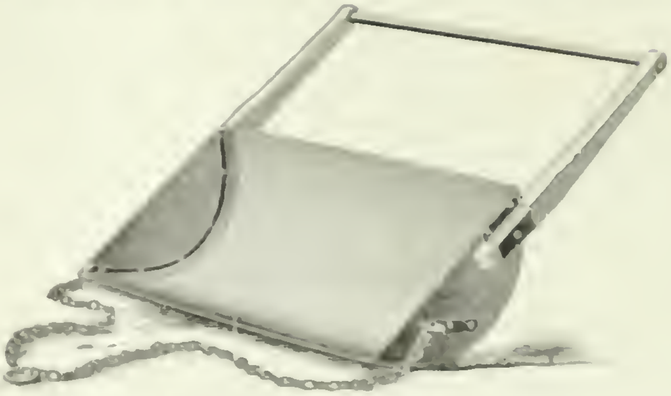

Fig. 2. Haslup Side Scraper

In Fig. 2 we show a "Haslup" side scraper, manufactured by the Sidney Steel Scraper Co. of Sidney, Ohio. It is meant entirely for ditch work, although it can be used for shallow trenches. It gets its name from the fact that its shape allows it to [illegible] the side of a ditch, instead of [illegible] as a drag scraper has to be worked. The side scraper does rapid work in making shallow, narrow ditches and also in cleaning out ditches. It can also be used in wider ditches. It is made of metal like a drag scraper, and the shape of its handle facilitates its work.

Unless the material is very soft or sandy, in using all of these scrapers it is necessary first to loosen the earth in the trench or ditch by plowing or some other means. [illegible] it is possible to [illegible] some way of loosening the ground without [illegible] into the trench or bank, [illegible] a plow with a team [illegible] in the trench or ditch is quickly [illegible], as it [illegible] impossible to [illegible] the sides of the trench or ditch. It is for this reason that scrapers have been little used for trench work, but the sloping of ditches admits of a much greater use of scrapers, and wheel scrapers can readily be used in ditches. Where the earth is to be carried some distance from the ditch and spread out, No. 1 wheel scraper can be recommended, as the driver can load such a scraper without help [illegible] and [illegible] the dump [illegible]. Thus in many cases [illegible] work can be done by [illegible] with [illegible] than with drag scrapers. [illegible] a Fresno scraper will do work cheaper than a [illegible]. The [illegible] wheel scraper, manufactured by [illegible] & Sons Manufacturing Co. of Kansas City, Mo., is a scraper built with a platform at the rear of the frame for the driver to ride upon. The levers are so arranged that they may be operated by the driver from this platform, and consequently this wheel scraper is well adapted for ditch work as well as other classes of construction.

On account of the difficulty of loosening the earth for scrapers, [illegible] have been invented and some contractors use a number of [illegible] of power scrapers.

One of the simplest of these is known as the [illegible] Excavator and Loader, sold by the [illegible] Equipment Co. of Milwaukee, Wis. This excavator was not designed primarily for trenches or ditches, but for other [illegible] work [illegible] any width of [illegible] to be made below the surface of the ground and where the material has to be elevated. It is well adapted to trenching. An A frame is set on the ground and an excavating scraper, somewhat similar to the ordinary drag, is [illegible] and after the scraper is loaded [illegible] it is raised to means of the A-frame to the ground, and automatically dumped on the surface or into wagons or carts. It can be operated either by horses or by other power as steam or electricity. In hard materials power should be used and not horses. With this A-frame it would also be possible to loosen earth in a trench with a plow, thus saving taking stock into the trench or pit.

The Heffron Trenching Machine, manufactured by the Heffron Trenching Co., Cincinnati, Ohio, is a somewhat similar machine, designed for trench work, although it can also be used for the excavating of pits and cellars. It is operated by a hoisting engine. There is a platform kept in front of the trench with a runway from the trench to the platform. On the platform is a frame over which the lines operate running from the engine to the scraper. The earth is excavated with the scraper, the pan of which is shaped somewhat like that of a wheel scraper. The scraper loaded in the trench is pulled up the inclined runway where it is automatically tipped, and the load is dumped through a trap into a wagon or cart to be hauled away.

When it is necessary to loosen the earth before using the scraper, a plow is operated by the hoisting engine, so it is never necessary to use picks. The plow weighs 700 lbs. It is stated that this machine can be operated on streets where there is gas, water or other pipes, without disturbing or cutting them, and can be moved as required on the work in about 20 minutes. The writer is informed that, where plowing is necessary, that from a trench 20 ft. deep, an average of 130 cu. yds. in ten hours can be excavated. The following crew is needed for the work:

1 engineer	$ 3.00
1 foreman	1.50
4 men at $2.00	8.00
Coal and supplies	2.50
Total	$15.00

This gives an estimated cost of 11.5 cts. per cu. yd., which is low for a trench 20 ft. deep.

Such power scrapers can be used on small jobs as well as large ones. There are, however, a number of power scrapers of large capacity that are meant to do excavation for many classes of construction, and all of these can be used for trenches and ditches, especially those trenches that are wide enough to suit the scrapers. In deep trenches, where shoring and cross braces are needed, it is not possible to operate scrapers, except to start off the work. This is frequently done.

One of these power scrapers is known as the Heyworth-Newman Excavator and is sold by James O. Heyworth, Harvester building, Chicago. The scraper is operated by a derrick or derrick car, locomotive crane or similar device and naturally such a plant is expensive, hence the scraper can only be used where the size of the job justifies the expenditure of capital for such an outfit. This scraper is made of heavy boiler plate, and is so shaped as to give the greatest possible strength with the least weight. The mouth of the scraper has a wide opening. In dumping, the bucket or scraper is inverted, and as it has a rounded back and an open top, it is stated that the material can never become packed. Consequently it is impossible for the material to stick in the scraper. In soft materials a plain heavy lift is used on the scraper, but in hard materials standard shaped steam shovel teeth are used. The bucket is dumped by continuing to haul on the fall line until the sheave block is drawn up against the stop on the boom. Further hoisting then tilts the bucket bottom up.

The Lidgerwood excavator is a somewhat similar device, although the scraper differs in shape and in arrangement of lines. The general method of operation is similar, and its range of work is about the same.

One of the best known power scrapers is called the Page bucket. This bucket and the Lidgerwood excavator are manufactured by the Lidgerwood Manufacturing Company, of 96 Liberty street, New York. The method of operating the bucket is similar to the two scrapers just described. The Page bucket has had an extensive use for various classes of excavation within the past five years, and it has been used for sewer trench work at Gary, Ind. See Engineering-Contracting Aug. 5, 1908.

One of the earliest types of power scrapers placed on the market was the Armstrong excavator. This scraper has been improved and is now manufactured by the H. Channon Co., Chicago, Ill., and is known as the Channon scraper excavator. The general operation of this scraper is the same as those previously described.

The Browning Manufacturing Co., of Mansfield, Ohio, make the Browning scraper bucket, which is adapted to the same class of work as the other power scrapers.

The Brown Hoisting Machinery Co., of Cleveland, Ohio, also make a scraper bucket. Both of these makes have been used in connection with locomotive cranes. In trench work a locomotive crane is frequently useful in handling pipe or other materials that have to be placed in the trench.

The Bagley grader, made by the Bagley Grader Co., of Tacoma, Wash., is also a power scraper, designed for grading work, but can be used for trenching. Derricks or cranes are not needed to operate it as it drags along the ground by a direct pull from the engine. It is necessary to have a deadman in the ground to work the back line of the scraper.

(To be continued.)

Some Notes on Methods of Making Excavations in River Beds by Dredge and by Cofferdam, With Some Percentages of Costs.*

BY CHARLES Y. DIXON.†

The Detroit River is about 28 miles in length, and in the southern portion of about 15 miles length, there are a number of islands which divide the river into several channels. The river has ample depth for navigation purposes from its head to about 10 miles above its mouth, where it becomes shallower and for the greater part of this distance the river bottom consists of limestone bedrock overlaid in some places with clay, sand, and boulders. It is through this portion of the river that channel improvements have been necessary. For a length of about one mile about five miles from the river's mouth, in that part known as Lime Kiln Crossing, the bedrock bottom is without the earth covering, and originally the safe draft for vessels over it was about 12 or 13 ft. near the Canadian shore. When appropriations were first made by Congress for an increased depth, immediate results were desired, and it was here that the work was done. The improvement of this channel in Canadian waters was continued with later appropriations, and it is still in progress.

As a result of these improvements up to 1892, there was a least depth of about 16 ft, for a channel of 300 ft. width in the narrowest places, although in some localities the depth had been increased to 20 ft. for short distances. During 1892, a general project was adopted by Congress providing for 20 ft. depth throughout a channel of safe navigable width. Under this project, up to 1897, a channel of the prescribed depth and of 300 ft. or more width had been excavated through all the shoal areas originally specified; and until 1902, the improvement consisted in increasing the depth and width at angles, exposed places in the open lake, and in removing many isolated shoals of small extent that were found to interfere with safe navigation.

Prior to 1902, the projects for channel improvements provided for depths at a midsummer stage of water, but as a result of the fluctuation in the water surface due mainly to storms, there was often a least depth of only 17 ft. instead of 20 ft. as contemplated by the project. Therefore a new general project was then adopted, providing for 600 ft. width and 21 ft. depth at a low water stage, or about 23 ft. depth at the reference plane formerly used. This made necessary the further deepening of all that portion of the channel which had been improved up to that time, together with much additional area. Work under this project is now near completion. The total appropriation for Detroit River improvement under the above mentioned projects is about $4,000,000, and of this amount about $150,000 is still unexpended.

As a result of the rapid increase in Great Lakes tonnage at this time, it was evident that the improvements contemplated by the existing projects would soon become inadequate for safe navigation. Therefore, in 1907, Congress made appropriations providing for a number of additional improvements, among others being one of $6,670,950 to secure a second channel through the shallow portion at the mouth of Detroit River. This channel is to be of 22 ft. depth at a low water stage and 300 ft. wide from its north end to Bar Point, a distance of six miles, thence widening to 800 ft., which width is maintained to deep water in Lake Erie, a distance of six miles.

During the summer of 1907, accurate surveys were made along the Livingstone Channel, specifications were prepared, and four contracts at Sections 1, 2, 3 and 4 were let for the entire improvement at a cost of about $400,000 less than was estimated. The work to be done under these several contracts will be paid for on the basis of bank measurement of material removed, except at Section 4, where payment will be made on the basis of scow measurement. These contracts are described more in detail as follows:

Section 1.—Contractors, Great Lakes Dredge & Dock Co. of Chicago, Ill. The channel area has a length of 5,800 ft. and a width of 300 ft. There is to be removed limestone bedrock with some overlying earth and boulders, all of about six ft. average depth of material, to the extent of 392,000 cu. yds. at an average price of $1.72 per cu. yd., or a total cost of about $673,206.

Section 2.—Contractors, Grant, Smith & Co. and Locher of Chicago, Ill. The channel area has a length of 7,500 ft. and a width of 300 ft. This area has been divided into two portions, one of 4,000 ft. length to be surrounded by cofferdams and excavated in the dry, and the remaining

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*Condensed from the "Michigan Technic," for June, 1909.

3,500 ft. length to be paid for as it excavated by the usual subaqueous method. Excavation by the dry method will include earth and boulders of 5 ft. average depth of material overlying bedrock to the extent of 108,000 cu. yds. at $0.60 per cu. yd., and limestone bedrock of 16.8 ft. average depth of material to the extent of 718,000 cu. yds. at $1.20 per cu. yd., and by the subaqueous method, there will be removed earth and boulders of 8.7 ft. average depth of material overlying bedrock to the extent of 292,000 cu. yds. at $0.78 per cu. yd., and limestone bedrock of 4 ft. average depth of material to the extent of 112,000 cu. yds. at $2.08 per cu. yd. In addition, lump sums are to be paid of $25,000 for construction of cofferdam, of $15,000 for partial removal of cofferdam and of $5,000 for partial removal of old railroad pier. The total cost of this work will be about $1,278,110.

This contract also requires the channeling of the sides of the channel from the rock, but no payment will be made therefor directly, as the prices bid for the removal of material include this cost. It is apparent that better results may be obtained by the dry method than by the usual subaqueous method of rock excavation, as the sides of the channel may be left perfectly smooth and the bottom cleared of all loose material, thus making the resulting improvement much safer for navigation. The dry method is well adapted to this section on account of the shallow water making the cost of cofferdams small as compared to the amount of material within the inclosed area. The material for the cofferdam was excavated from the channel area outside of the cofferdam, loaded on flat scows, towed to the site of the dam by launches, and there unloaded by steam shovels. The details of this cofferdam, its method of construction and actual site were left mainly to the contractors, who are held responsible for its maintenance.

Section 3.—Contractors, P. R. McNaughton and O. E. Dunbar of Buffalo, N. Y. The channel area has a length of 18,250 ft. and width of 300 ft., except for the south 1000 ft., where the width increases from 300 to 550 ft. There is to be removed sand, clay and boulders of 7.8 ft. average depth of material overlying bedrock to the extent of 1,610,000 cu. yds. at $.18 per cu. yd., and limestone bedrock of 1.3 ft. average depth of material to the extent of 820,000 cu. yds. at $2.96 per cu. yd., the total cost being about $2,700,750.

Section 4.—Contractors, G. H. Breymann & Bros. of Toledo, O. The channel area has a length of 29,000 ft. and width of 300 ft., except for the north 1000 ft., where the width increases from 300 to 800 ft. There is to be removed sand, clay, silt, boulders and hardpan of about 14 ft. average depth of material to the extent of 7,500,000 cu. yds. at a cost of 7.6 cents per cu. yd., or a total of about $561,750.

At Section 4, payment is based upon scow measurement for the reason that the contractors generally expected the material to drift and fill in after dredging and before the final survey, making it necessary to dredge over the same areas several times and receive no payment therefor. This would not be necessary, as surveys in this locality made several years after the completion of former contracts showed little if any change in the improved depth. The contractors would raise their price high enough, however, to allow for such filling in as they expected, therefore it was deemed advisable to make payments on the basis of scow measurement.

Where conditions will permit of accurate surveys being made, it has been found preferable to make payment for material removed on the basis of bank measurement, but this method is manifestly unfair where the material is unstable and liable to drift and fill in after dredging. Provision is also made for payment at the full contract rate for all material above the required depth, at one-half the contract rate for the next two ft. of depth, and no payment for material excavated below this subgrade nor for material excavated outside of the specified area. Whatever method of making payment is used, a Government Inspector is stationed on each dredge and charged with the duty of keeping a complete record of work done and of enforcing the provisions of the specifications. Some of the reasons which make the scow measurement method of payment objectionable are as follows: Under this method the agents of the contractors in their desire to be allowed enough often scow more than the actual material in the scows, and also, where the material is easily removed, there is a tendency to excavate too deep or outside of the specified area, all of which, if the Inspector on the dredge is honest and he usually is, leads to constant disputes. There is also the constant temptation for the Inspector to get along smoothly by allowing all that is asked, and at times perhaps to receive a valuable present in return without any check upon the work after it leaves his hands. This statement is not intended to reflect upon the contractors, as the writer has usually found them wanting only what is due them, but their agents are often overanxious to make a good showing for their work. This is all obviated by the bank measurement method, as the amount finally received by the contractor is dependent entirely upon computations made in the office from surveys. If any irregularity then exists, the Assistant Engineer in charge of the work should know of it and be held responsible. The writer may be somewhat selfish in this matter, but he would much prefer to have the work so conducted that he has the only chance at an irregularity.

A brief statement of the method of preparing specifications, the letting of contracts and of executing the work under the contract may be of interest.

There must first be a demand for the work, and then instructions are received from Congress through the Chief of Engineers and the Engineer Officer in charge for the making of a preliminary survey and estimate. This survey should be in such detail as to enable the approximate cost to be determined. For this purpose the character of material should be ascertained so that the approximate cost per cu. yd. may be known, also, soundings must be obtained from which are computed the approximate quantities. Care should be taken that this preliminary estimate be large enough to cover the work contemplated but, in the experience of the Assistant Engineer, it should not exceed the actual cost by more than 20 per cent. When completed, this estimate is transmitted to the Engineer Officer in charge of the work, who is a West Point graduate and regular Army Officer, and it is finally reviewed by Congress. If that body deems the improvement warranted, an appropriation is made, and authority is given the Engineer Officer to enter into formal contract or contracts for its execution. Then other surveys are made more in detail than the preliminary, and from these is obtained the information which enters into the specifications intended to govern the contract. The specifications being prepared, they are transmitted through the proper channel to the Chief of Engineers, and after approval, advertisements are made in the leading journals for a period of about thirty days, requesting contractors to submit bids for the performance of the work as advertised. These bids are also sent to the Chief of Engineers, with the recommendations of the Engineer Officer in charge as to their acceptance or rejection. Should the bids be rejected, new bids are called for in the same way as before, but if approved, authority is given to enter into contract and usually within ten days thereafter the actual work of excavation is commenced.

The surveys to which reference has been made consist in the taking of soundings at regular intervals, usually in the vicinity of [illegible] squares, and in determining the character of material. The soundings are taken through holes bored in the ice during the winter months, if practicable, or from boats [illegible] at the required intervals, stretched across the proposed channel, or from a [illegible]. The character of material may be determined by borings, or by preliminary dredging at various places along the site of the work. All [illegible] of soundings, borings or dredging are determined by transit [illegible] from shore stations [illegible] forming a part of an accurately established triangulation system. While making these surveys, water gage readings are taken at frequent intervals at a convenient point on shore, the zero of this gage being at the plane of reference. The soundings and depths of rock as determined by the borings are then reduced by applying the corrections indicated by the water gage readings.

The reference plane is selected arbitrarily prior to the preparation of the specifications, but after entering into contract it cannot easily be changed while the contract is in force. The reference plane now used in connection with Detroit River improvements corresponds to a Lake Erie stage of 570.8 ft. above mean tide at New York. This stage is the lowest monthly mean since continuous observations have been recorded, and is about two feet lower than the average monthly mean stage prevailing for the past ten years. Under bank measurement contracts, surveys are made of [illegible] before beginning work and after its completion. Upon these two surveys alone depend the quantities for which payment is made. Scow surveys are also made at various times during the progress of the work for the purpose of correcting partial payments which had been estimated approximately from scow measurements.

The specifications governing contracts should give complete information as to the work contemplated, and state clearly all conditions which may affect the price of the work, but these specifications should not be burdened with provisions which are not intended to be rigidly enforced. Bidders are always expected to make their own investigations as to the nature of the work and the difficulties affecting the [illegible], but [illegible] may base their prices upon information furnished in the specifications.

Where earth alone is to be removed, the [illegible] type of [illegible] dredge is [illegible], [illegible] about two feet below the required depth. A drag consisting of a heavy [illegible] beam [illegible] suspended from each end of a scow [illegible] is then used to find all [illegible] that may be left. When dragging the [illegible] area, the [illegible] beam is usually set about one foot below the required depth. This [illegible] is only effective in soft material but it does good work there, although a [illegible] redredging is necessary in places before the entire area can be cleared.

For rock excavation, where there is overlying earth, this earth is first removed by dredging, then the rock is broken up by drilling and blasting. The broken rock is removed by dredges, and following this the area is cleared of all loose rock projecting above the required depth by derrick scow with diver, each rock being chained by the diver and hoisted up separately. The operation of a derrick scow with diver is slow and costly, and the contractor usually avoids this as much as possible by dredging to a much greater depth than required, so that nearly all of the loose rock remaining will be below the required depth.

After an area has been thus improved, either in earth or rock excavation, the contractor claims the completion of his contract within that area. Then the Government agent in charge of the work, as a means of inspection, causes this area to be swept by a scow or raft having iron bars suspended to the depth required by the contract. Should this inspection disclose any material it is removed either by dredge or derrick scow or both as is most suitable. When an area thus inspected is eventually found clear at the required depth, that portion of the work is accepted as completed. During this inspection, the stage of water is constantly noted and the depth of the iron bars is adjusted to agree with any change in this stage.

With regard to the operation of drilling and blasting rock by the subaqueous method, generally, the holes are drilled at the corners of 5-ft. squares to a depth of about four feet below the sub-grade. The result of a blast is the breaking up of the rock in the shape of an inverted cone, the apex being the bottom of the hole, and when the holes are drilled to the depth and distance apart stated the highest points of unbroken rock will be well below the depth of pay material. Usually, each hole, as soon as it is drilled, is loaded with 60% dynamite in an amount of about one pound for each linear foot of drilling, and the dynamite discharged immediately without moving the drill-boat or otherwise interfering with its operation. At times, however, when working in rock of several feet depth, each hole is charged with dynamite when drilled but not exploded until after a large quantity of dynamite has been thus placed, in some cases as much as two tons, and then the whole is exploded by firing only the last hole charged. When this is done the drill-boat, for safety, must move to some distance, and the resulting shock usually causes buildings on shore in the vicinity to tremble. The contractors much prefer these large blasts because of the easier drilling. When each hole is fired separately, the rock at the adjacent hole is shattered at the surface and the hole is not easily drilled; when fired in series, the rock is undisturbed and is more easily drilled, except at the hole adjacent to the last blast. It is believed, however, that the rock is broken up more thoroughly when holes are fired separately than when fired a number at a time.

It is a common saying that familiarity breeds contempt, and this is only too true with men who are accustomed to the use of explosives. Several accidents have resulted from the use of dynamite on the Detroit River, some of them of a serious nature, but it is believed that they can all be attributed to carelessness. The most serious accident directly in connection with this work occurred on August 14, 1908, when the premature explosion of dynamite in one of the last of a number of holes already charged exploded the entire amount, a total of 4,440 pounds. The drill-boat was completely wrecked, although fortunately it did not sink, and the entire crew of 13 men were injured, some of them quite seriously. This last hole had been partly charged with dynamite, when a small piece of rock fell into it and prevented the loading tube from re-entering in order to complete the charging. The steam drill was used to clear the hole, and by lowering the drill too far the dynamite already placed was struck and exploded. No one but the man who had become too familiar with dynamite would risk his life by attempting with a steam drill to clear out a hole that had been partly charged. This dangerous practice was most uncommon and was unknown to the contractors, who were in no way to blame. It is unnecessary to state that these same men will not again attempt this trick. In this connection, it may be stated that one careless man in a crew will frequently endanger the lives of the others, even though they exercise the greatest care.

The amount of dynamite used on the work during the past year was 465 tons, and it is probable that during each of the next two years this amount will be about 800 tons. Prior to the past season, all dynamite used on this work was received by rail direct from the factories, but during the past season a factory was established on a small island near the site of the work and one of the contracting firms manufacturers dynamite for its own use there. The process of this manufacture is quite interesting, also dangerous, and lest we become too familiar with it we will pass to other equally interesting work.

The improvement already described is such as has been continued in this vicinity for years past, although the operating machinery has been improved and perfected from time to time. There is now a new method used in this improvement, at least it is new to Detroit River. As has been stated in the description of the specifications relating to Section 2 of Livingston Channel, a portion of this area was required to be surrounded by cofferdams and the inclosed channelway excavated in the dry. The contractors for this work commenced operations on April 14, 1908, and a portion of the area was surrounded by cofferdams by Oct. 4 and the pumps started for unwatering the inclosed area. The work of drilling and blasting the rock was commenced on Oct. 20, and one steam shovel began excavating the broken rock on Oct. 25.

It was expected by the U. S. Engineer and stated in the specifications that the entire area of 4,000 ft. length would be surrounded by cofferdams, and this was at first undertaken by the contractors, but when the dams had been nearly completed up to the water surface, the contractors decided to put in an intermediate dam dividing the area into two portions, one of 2,800 ft. length and the other of 1,200 ft. length. With the larger portion, there is little if any earth covering the rock, but within the smaller portion there is an earth covering of several feet depth. The contractors wished to remove this earth by dredging, and to make use of it for cofferdam construction as it was the most suitable material at hand. This would also insure the completion of the dam around the larger portion before the end of the season and permit of work of excavation during the winter months.

The specifications require the removal of only so much of the cofferdam as crosses the channel and lies within 50 ft. of its sides, and the provision is also made that the west dam shall be at least 350 ft. from the channel to permit of future widening should this at any time be necessary.

When the unwatering of the area was begun, in addition to two 12-in pumps, there were used 48 6-in pipes through which air was forced from the compressor plant. These pipes rested upon the river bottom in about 12 feet of water, and the air was admitted at their lower ends. This air lift caused the pipes to flow full of water until there was a lowering of about 5 ft. when they ceased to be effective owing to the air being forced through the water instead of raising it. After the air lift had been abandoned, the work was continued by the pumps and completed in 15 days' total time. The area unwatered was 2,800 ft. long, about 1,700 ft. average width, and about 7 ft. average depth, containing about 250,000,000 gallons.

The plant engaged on this work is as follows:—One air compressor plant consisting of two compressors, one of 300 h.p. and the other of 700 h.p.; two 12-in. and one 8-in. steam pupms; three steam shovels; three channeling machines; eighteen air-driven drills; three cableways with towers; one small locomotive with several flat cars for handling supplies; two scows equipped with machinery for unloading earth and rock to form cofferdams; five flat scows for carrying earth and rock; and three launches. The number of men employed is now about 200, but this number will soon be greatly increased.

The air compressor plant furnishes power for operating 18 drills, 3 channeling machines, and 3 cableway conveyors of excavating material.

The rock is drilled and blasted in much the same way as described for the subaqueous method, except that instead of the drills being mounted upon boats they are small and portable, but the results secured are the same at about one-third the cost. The broken rock is excavated by self-propelling steam shovels and deposited in skips of about 2.5 cubic yards capacity, and carried by the cableway conveyor outside of the channel area and there deposited. One cableway conveyor is operated in connection with each steam shovel. The scheme for the mid-air dump of the skip is the invention of Mr. C. H. Locher, one of the contractors, who devotes nearly his entire time to the supervision of this work. This invention consists in throwing one of the cables towing the skip upon a larger drum at the power house, causing this cable to travel faster until the pull becomes sufficient to dump the skip at the desired place. This clever device has been the means of greatly reducing the cost of excavation by the dry method.

The channeling machines are operated ahead of the drills, and care must be exercised in blasting near the sides of the channel that the channeled face be not broken. Provision is made in the specifications that 50 cents be deducted from money due the contractors for each square foot of channeled face of wall which may be broken as a result of their operations. The maximum depth of material to which the channeling machines may operate is about twelve feet. It will therefore be necessary to make two cuts in order to complete the required depth, and at the top of the second cut there will be an offset in the channeled wall of about nine inches. The width of the channel at the top of the walls therefore must be about 301.5 ft. to permit of the bottom width being the required 300 ft.

The following interesting tables relating to the different items of cost incident to the work of rock excavation have been prepared by Mr. Harry Hodgman with the assistance of Mr. N. R. Macklem, and they are here submitted in the hope that it will not prove too hard [illegible]

TABLE I—COST OF SUBAQUEOUS ROCK EXCAVATION, LIME KILN CROSSING, DETROIT RIVER (OLD CHANNEL)

Designation of Item	Percentage of total cost
Drilling and charging holes	[illegible]
Explosives	19.31
Dredging	41.28
Clearing area of loose rock	[illegible]
Total	100.00

TABLE II—COST OF ROCK EXCAVATION BY DRY METHOD, SECTION 2, LIVINGSTONE CHANNEL, DETROIT RIVER

Designation of Item	Percentage of total cost
Pumpage, initial	[illegible]
Pumpage, supplementary	[illegible]
Drilling	[illegible]
Explosives	17.89
Excavating by steam shovel	[illegible]
Hauling and dumping by railway to 400 ft. dist	16.17
Channeling	[illegible]
Cofferdam construction	[illegible]
General repairs	[illegible]
Total	100.00

Table I gives the average percentage of items of cost under three different contracts at Lime Kiln Crossing. Under the first of these contracts, the work was performed by Jas. B. Donnelly, of Buffalo, N. Y., and completed on October 27, 1903, and under the last two contracts, the work was performed by the Dunbar & Sullivan Dredging Co., of Buffalo, N. Y., and completed on December 15, 1906, and December 5, 1908. The material removed under these three contracts was Dolomitic limestone of Silurian formation in a total amount of 533,052 cu. yds.

Table II relates to excavation by the dry method at Section 2, Livingstone Channel. As this work is but just commenced, the figures given in this table may be changed greatly as the result of more complete data. The material removed under this contract is of the same character as that stated for Lime Kiln Crossing.

The Department of Railway Engineering of the University of Illinois has recently erected a drop testing machine which is identical in design with the standard machine of the Master Car Builders' Association. This apparatus will be used in making impact tests of such materials as car couplers, wheels, axles, etc. It consists essentially of a spring supported anvil weighing 20,000 lbs. (upon which is placed the specimen to be tested), and a hammer weighing 1,640 lbs., which runs in vertical guides rising at either side of the anvil. This hammer may be dropped in these guides from any height up to 50 ft. The addition of this machine to the existing equipment of the College of Engineering of this Institution, renders it possible to make there tension, compression, bending, and impact tests of all materials of construction, on specimens of the full size ordinarily met with in practice. Through the courtesy of Mr. A. W. Gibbs, the Pennsylvania R. R. Co. furnished the drawings and loaned the patterns for the construction of this machine. The Cleveland, Cincinnati, Chicago & St. Louis R. R. Co., through its Superintendent of Motive Power, Mr. William Garstang, has donated to the University its services in connection with the work of construction and assembling the machine, which was done at the Urbana shops of this company.

Through the application [illegible] to the metallurgy of copper [illegible] 000 of that metal which was formerly lost, is now recovered annually.

Roads and Streets Section

Note: This Section is devoted to methods and costs of road and street construction. It will cover road building in all its details, the construction of pavements, sidewalks and gutters, the testing and use of paving materials and the machinery and tools used in road building and paving.

The Theory of Economic Road and Street Design and Location.

Selecting the Type of Wearing Coat.—The wearing coats commonly used for road and street pavements may be divided into 6 types:

Type 1. Granular mineral bound with mineral jelly.

Type 2. Granular mineral bound with bitumen.

Type 3. Granular mineral bound with Portland cement.

Type 4. Stone blocks.

Type 5. Wooden blocks.

Type 6. Brick.

By the term "granular mineral" we mean fragments of mineral matter of any size from dust up to fragments as large as hens' eggs or even larger, whether the fragments have been produced artificially by crushing or pulverizing, or by the forces of nature.

By the term "mineral jelly" we mean the "colloids" which Cushman has proved to be the cementing element of rock dust, which causes macadam to bind, and to which the "sticky" properties of clay are attributable.

Type 1 includes:

(a) Sand-clay roads.
(b) Gravel roads.
(c) Shell roads.
(d) Macadam.

Type 2 includes:

(a) Oiled roads.
(b) Tar macadam, or tar concrete.
(c) Asphalt macadam, or asphalt concrete.
(d) Asphalt pavement, (1) sheet and (2) block.
(e) Bitulithic pavement.
(f) Petrolithic pavement.

Type 3 includes:

(a) Concrete.
(b) Macadam grouted with cement (Hassam pavement).

Types 4, 5 and 6 are self-explanatory.

If noiselessness, cleanliness and slipperiness are not governing considerations, the type of wearing coat to select is the one that shows the minimum annual cost of interest and maintenance. The item of maintenance is so largely a function of the amount of traffic and the item of first cost, on which the interest depends, is so largely a function of prices of materials and transportation costs, that [illegible] the generalized statement that a certain type of pavement is always "best." [illegible] road.

There are [illegible] the quarry, that macadam is several times as expensive as gravel. [illegible] it may be found that the increased cost of maintenance of the gravel road is far more than offset by the increased cost of interest on the investment in a macadam road.

In [illegible] from Type 1 we must hereafter have in mind the amount of automobile traffic that is to come upon the road. The mineral jelly that binds the fragments that compose pavements of Type 1 is often so small in quantity and so weak, especially when it becomes dried out, [illegible] that the surface fragments are easily displaced [illegible]. This type of wearing coat is [illegible] to roads having little automobile traffic, and to parts of the country where rains are sufficiently frequent to prevent the mineral jelly from drying out. [illegible] even after it has dried out, the mineral jelly is restored to its original condition by wetting it.

Wearing coats of Type 2 are usually limited in life [illegible] exposed to the air and in time become brittle. There are comparatively few asphalt pavements that have had a life of much more than 20 years even where the traffic has been insignificant, for under the ordinary methods of treatment asphalt usually loses much of its binding power after being exposed in a thin sheet for 20 years. Undoubtedly there are asphalts that develop brittleness more slowly than other asphalts. The writer has noticed particularly the remarkable preservation of its original elastic qualities shown by some of the crude asphaltic oils of California used in sidewalk construction, even where exposed for 18 years. Certain tars have shown a life of more than 25 years in tar macadam pavements.

In spite of all these facts, in the present state of our knowledge of bitumens an engineer is scarcely justified in estimating a life of more than 20 to 25 years for any of the pavements of Type 2. This forms an added reason why the thickness of wearing coats of this type should be as little as is consistent with their holding together under traffic.

On the other hand, Types 3, 4 and 6 seldom "rot," or disintegrate because of chemical change. On a street subject to very light travel, there is no reason why a brick pavement should not last a century or more, if a good quality of paving brick is used and is placed upon a proper base so that settlement does not occur. [illegible] question of economy.

Type 5, wooden blocks, [illegible] the process of creosoting has given wood blocks a life [illegible] as asphalt, so far as its resistance to chemical change is concerned. Creosoted timber [illegible] can certainly be depended upon to withstand the elements for at least 25 years. In fact, timber ties impregnated with only 10 lbs. [illegible] of creosote [illegible] have lasted 30 years on the Eastern Railway of France and there are many other instances of [illegible] of creosoted wood.

Having assigned the probable life of a wearing coat under the given conditions of traffic, the next step is to estimate its first cost in detail. To do this it is wise not to rely on contract prices, but to make an independent estimate of materials and labor, using local prices and wages. This [illegible] all odds, the most satisfactory method of estimating the probable cost of any engineering structure, for many reasons, but it is particularly advantageous in that it often leads an engineer to make radical changes in design with a view to using cheaper materials or a design in which both materials and labor are economized. There are now sufficient data in print to enable an engineer to estimate the actual cost of almost any kind of pavement with tolerable accuracy, once the local prices and conditions are known.

For this estimate of cost the unit should be the square yard? No, *the square yard one inch thick*. Then different wearing coats can be readily compared on the basis of the same thickness, as well as on the basis of different thicknesses.

It will be found that, in most parts of America, the actual cost of a brick wearing coat is approximately 25 cts. per sq. yd. per inch of thickness, and that the cost of an asphalt wearing coat (averaging the cost of the "binder coat" with the "surface coat") is also approximately 25 cts. per sq. yd. per inch of thickness. As before stated, there are very few streets where the traffic is great enough to justify a thickness of wearing coat greater than 2 ins. for either brick or asphalt.

It is well to bear in mind that a concrete base can frequently be laid for 10 cts. per sq. yd. per inch of thickness, and that it seldom exceeds 12 cts. per sq. yd. per inch in thickness. If this fact is always remembered, there will be fewer pavements designed with thick wearing coats; for, if a great total thickness of pavement must be had, it will be secured by adding to the thickness of the cheap base and not to the thickness of the expensive wearing coat.

Stone block pavements may be said to average about 30 cts. per sq. yd. per inch of thickness of the stone wearing coat—including, as in the other cases, all materials and labor required for the wearing coat in place on the street. Therefore, so far as cost per inch of thickness is concerned, stone block is not much more expensive than brick or asphalt. The cause of the high cost of stone block pavements is found in the fact that the wearing coat never has a thickness of less than 5 ins. and is usually 6 ins. thick, which, as we have said, is a thickness wholly unnecessary for brick, asphalt or the like. The cost of stone blocks is largely the cost of the labor of splitting them to the desired size and shape. Since the cubic contents of similar blocks varies as the *cube* of any linear dimension, whereas the area of surface to be dressed varies as the square of any linear dimension, it follows that the cost of a stone block per cubic foot increases very rapidly as its size diminishes. Hence the economic limit of small size is soon reached. In addition to this, it is increasingly difficult to split small stones into regular forms on account of the tendency of chips to cleave off. Finally, stone blocks are no longer used except for very heavy traffic, or on very steep grades where the best sort of a foothold is required. Under heavy traffic, small independent blocks of stone would crack or crush. These are the reasons why a thin wearing coat of stone blocks is impracticable; and, being impracticable, a stone block wearing coat is not as economic as other types of pavement, except under comparatively rare conditions.

Summary.—In the eleven articles of this series we have endeavored to discuss road and pavement design entirely upon economic principles. We began by showing that methods of selecting pavements sanctioned by eminent authorities have had the appearance of science without the reality. To assign different percentages to the different qualities of a pavement, the total amounting to 100 per cent in the "perfect pavement," is pseudo-science of the worst sort. It attempts to crown with seeming wisdom the head that should wear the dunce cap in the school of paving economics.

We have shown that road design and location should not be attempted without adopting the same general principles now universally applied in scientific railway location; but we have also shown that there are many marked differences between railway transportation and road transportation, such, for example, as the fact that on roads the loads travel entirely in one direction.

We have also shown that since the tractive power of a horse is not a constant, the problem of economic ruling grades is quite different from the same problem on a railway where locomotives are used.

We have shown that it is a fallacy to regard the value of team time as being less at one season of the year than at another, and that a definite value can be estimated and assigned to every working team day. When this is done, and when the average ton-mileage to be hauled annually over a given road is ascertained, road location problems can be solved scientifically.

We have shown that a pavement should be regarded as composed of a base and a wearing coat, the function of the base being to distribute concentrated wheel loads over the subgrade, and the function of the wearing coat being to present a smooth, durable, clean surface that reduces rolling friction.

We have shown that the vertical pressure transmitted through a granular mass varies inversely as the cube of the thickness of the mass, for all light pressures; and we have indicated how tests should be conducted to prove what the law of pressure distribution is for heavy loads.

We have shown that it is far cheaper to increase the bearing power of the subgrade by uniformly consolidating it with a rolling tamper (not a roller acting by surface pressure, but a tamping roller whose tampers penetrate the plowed earth) than it is to increase the thickness of the pavement base.

We have shown that the rattler test of pavement materials has always been more or less unsatisfactory, and is particularly so now that sheet pavements made with bituminous binders are so extensively used.

We have shown that the "wheel test," as we have termed it, is readily made, and gives not only a more rational test, but furnishes also data as to the tractive resistance of the pavement in its various states of cleanliness and of irregularity due to wear.

We have shown that most country roads should be paved with a single track (8 ft. wide) instead of with a double track, for existing traffic no more warrant double tracking all country roads than it warrants double tracking all railways.

We have shown, in brief, that to every step in road and street design or location there should be applied this criterion:

Is the design such as to secure the minimum annual cost of the sum of the elements of cost involved?

On roads one of the elements is the annual cost of teamtime required to do the hauling, another element is the annual interest on the investment, another element is the annual cost of repairs and depreciation; therefore the most economic design is the one that makes the sum of these elements a minimum.

It is high time that inflexible "standards" of road and street construction be abandoned. There can be no standard that is most economic under all conditions. A vast deal of nonsense has frequently permeated engineering discussions about standardizing construction. We may well be thankful that general standardizing has never gone farther than discussion. Unfortunately there is too much standardization already. Each problem in road and street design should be studied as a separate problem in economics; and it has been our attempt to indicate the general methods to be applied in attacking these problems.

We urge, finally, that every engineer should familiarize himself with actual detailed costs of labor and materials required to build roads and pavements, not merely to be able to estimate the probable costs of projected work, but to be able to make changes in designs and methods of construction that will reduce the cost of roads and pavements, and thus greatly extend the mileage of good highways in America.

Recent Specifications of the Massachusetts Highway Commission for Refined Tar and Asphalt Oils for Use in Highway Work.

In a discussion* of a paper on Sampittic Surfacing, before the American Society of Civil Engineers, Mr. H. W. Clark, Chemist Massachusetts State Board of Health, gave the following recently issued specifications of the Massachusetts Highway Commission for refined tar and asphalt oils for use in Road Construction.

SUGGESTED SPECIFICATIONS FOR REFINED TAR.

The tar shall be uniform in color, character, appearance, and viscosity, and shall have the following qualities:

(1) It shall contain not more than 0.5% of mineral matter or dirt.

(2) It shall have a specific gravity between 1.18 and 1.25.

(3) It shall not contain more than 14% by weight of free carbon.

(4) It shall contain no body which distils at a temperature lower than 225° cent.; not more than 10% by weight shall distil below 270° cent., and it shall contain at least 65% by weight of pitch or bituminous material remaining after all bodies up to 360° cent. have been distilled.

(5) When 20 grammes are heated in a flat-bottomed dish, 3 in. in diameter, for twenty-one hours, in an oven kept at a temperature of 100° cent., the loss shall be not more than 10% by weight.

(6) It shall be of such viscosity that 60 cu. cm., measured at room temperature (78° Fahr. or 26° cent.), shall, when at 100° cent., be not less than 85 sec. and not more than 240 sec. in passing through a viscosimeter orifice 5/64 in. in diameter, when acting under a head of 4¼ in.

(7) When 12½% by weight of the material is mixed with 87% by weight of sand, of such grade that all of it will pass through a seive having 10 meshes to the linear inch, and that practically none of it will pass through one with 190 meshes to the linear inch, and briquettes, 3 in. square and ½ in. thick, are made, such briquettes will harden to such an extent in seven days, at ordinary room temperature, that when they are laid flat and held by their edges by two parallel knife-edge bars, they shall not bend when a weight is suspended from a third knife-edge or parallel bar placed across their center, until

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*Proc. Am. Soc. C. E., May, 1909, p. 494.

this weight reaches 200 grammes, and they shall not break at less than 250 grammes, and the weight which causes bending shall not be greater than 80% of the weight which causes breaking.

SUGGESTED SPECIFICATIONS FOR ASPHALT OIL.

The oil submitted shall be of uniform color, appearance, general character and viscosity. It shall contain no matter not naturally present in an asphaltic oil, and shall fulfill the following requirements:

(1) It shall not contain more than 0.5% of dirt or adventitious mineral matter.

(2) It shall have a specific gravity of at least 0.97.

(3) It shall not contain more than 1% of matter insoluble in carbon bisulphide, and shall not contain more than 10.0% of matter insoluble in petroleum ether.

(4) It shall contain no body which distils at a temperature lower than 250° cent., and shall not lose more than 35% by weight by distilling to 400° cent.

(5) It shall be of such viscosity that 60 cu. cm., measured at room temperature (78° Fahr. or 26° cent.), shall, when at 100° cent., be not less than 5 min. nor more than 10 min. in passing through a viscosimeter orifice 5/64 in. in diameter, when acting under a head of 1¼ in.

(6) When 20 grammes are heated in a flat-bottomed dish, 3 in. in diameter, for twenty-one hours, in an oven kept at a temperature of 100° cent., it shall not lose more than 5% by weight.

(7) When 12½% by weight of material is mixed with 87½% by weight of sand, and briquettes 3 in. and ½ in. thick are made, these briquettes shall keep their shape and show some bond.

The Detailed Cost of 80,000 Square Yards of Brick Pavement and 40,000 Lineal Feet Cement Curb.

During 1905 and 1906, a large amount of brick paving and cement curb was built at Centerville, Ia., by contract. Mr. M. G. Hall required the inspectors to keep a careful force account of the work done, and the following data are a summary of the records thus gathered.

Purington paving bricks were laid on a concrete base, with a 1½-in. sand cushion between. The joints were filled with a 1-1 cement grout. Expansion joints of asphalt filler were provided from curb to curb, every 50 ft., and along each curb. The following costs do not include grading.

The concrete base was a 1-3½-6 mixture and it was machine mixed. There appears to have been a serious error made either in recording or in calculating the amounts of cement, sand and broken stone used, for, as will be seen below, Mr. Hall's data show about two-thirds as much of each of these materials per cubic yard as are required by a 1-3½-6 mixture. Mr. Hall's data were originally published in "Engineering News," April 2, 1908, and were not there analyzed as we have analyzed them below, which probably accounts for his failure to discover the discrepancy. This emphasizes the importance of using the cubic yard as the unit in summing up costs of concrete, instead of relying solely upon the square yard.

Our analysis of the costs of the 5-in. concrete base, for three jobs aggregating 58,000 sq. yds., shows the following:

	Per cu. yd. cts.
Sand wheelers, at 20 cts. per hr.	[illegible]
Concrete wagons, at [illegible] cts. per hr.	[illegible]
Men on mixer, at 2[illegible] cts. per hr.	[illegible]
Spreaders, at 22½ cts. per hr.	[illegible]
Tampers, at 20 cts. per hr.	[illegible]
Water boy, at 1[illegible] cts. per hr.	[illegible]
Extra men, at 20 cts. per hr.	[illegible]
Foreman, at 30 cts. per hr.	[illegible]
Coal for mixer, at $[illegible] per ton	[illegible]
Total labor	[illegible]

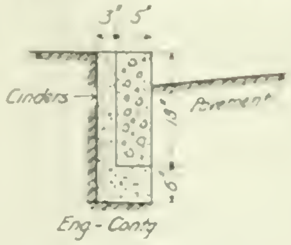
This is practically 18 cts. per sq. yd., exclusive of interest, depreciation and repairs on mixer. Since the concrete was 5 ins. thick, divide any of the above items by 7.2 to get the cost per square yard.

According to Mr. Hall's records, the cost of materials was as follows, when reduced to the cubic yard unit:

	Per cu. yd.
0.6 bbl. cement at $[illegible]	$[illegible]
0.33 ton sand at [illegible]	[illegible]
0.62 cu. yd. stone at $[illegible]	[illegible]
Hauling cement	[illegible]
Hauling sand	[illegible]
Hauling stone	[illegible]
Total materials	$[illegible]

The sand weighed 2,700 lbs. per cu. yd. and the stone weighed 2,626 lbs. per cu. yd.

Since the materials would have to be about 50 per cent more than above given to make a cubic yard of concrete rammed in place, the cost of materials, at the unit prices given, would be about $3.7[illegible] per cu. yd., instead of $2.47.



Section of Concrete Curb.

The cost of laying 78,000 sq. yds. of brick pavement was as follows:

	Per sq. yd. cts.
Brick wheelers, at 20 cts. per hr.	1.[illegible]
Brick layers, at 22½ cts. per hr.	0.88
Men spreading sand, at 22½ cts. per hr.	1.0[illegible]
Water boy, at 10 cts. per hr.	[illegible]
Other men, at 20 cts. per hr.	[illegible]
Foreman, at 30 cts. per hr.	0.41
Total	4.97

By comparing these items with costs given in Gillette's "Handbook of Cost Data," pp. 157 to 165, it will be found that items of wheeling brick and of spreading sand were unusually expensive.

By dividing the square yard cost of any item into the corresponding rate of wages, the number of square yards per hour is obtained. Thus each brick layer laid 22.5 ÷ 0.88 = 25.6 sq. yds. per hr., or 256 sq. yds. per day. Since there were [illegible] bricks per sq. yd., this is equivalent to [illegible] bricks per brick layer, which is an excellent output.

On another job, where 2[illegible] sq. yds. were laid, the cost of laying was as follows:

	Per sq. yd. cts.
Brick wheelers, at 2[illegible] cts.	[illegible]
Brick layers, at 2[illegible] cts.	[illegible]
Brick [illegible], at 2[illegible] cts.	[illegible]
Men spreading sand, at [illegible] cts.	[illegible]
Men [illegible] sand, at [illegible] cts.	[illegible]
Laborers, at 2[illegible] cts.	[illegible]
Water boy, at 1[illegible] cts.	[illegible]
Other men, at 2[illegible] cts.	[illegible]
Foreman, at [illegible] cts.	[illegible]
Total	[illegible]

There were brick layers averaging [illegible] sq. yds. per brick layer per day, and as there were [illegible] bricks per sq. yd., this is equivalent to [illegible] bricks per brick layer per day. There was [illegible]

The cost of the bricks ranged from 7[illegible]½ to [illegible] cts. per sq. yd., the following being a fairly typical cost of the materials and labor:

	Per sq. yd.
[illegible] bricks at $1[illegible] per M	$[illegible]
Hauling bricks	[illegible]
Sand for 1½-in. sand cushion at [illegible] cts. per cu. yd., delivered	[illegible]
Total materials	$[illegible]
Labor laying brick (as above, average)	[illegible]
Total	$[illegible]

The cement grout filling was a 1-1 [illegible] grout, the cost of which was as follows for [illegible] sq. yds.:

	Per sq. yd. cts.
Screening sand at [illegible] cts. per hr.	[illegible]
Dry mixers at 2[illegible] cts. per hr.	[illegible]
Wet mixers at 2[illegible] cts. per hr.	[illegible]
Sweepers at 2[illegible] cts. per hr.	[illegible]
Wheelers at 2[illegible] cts. per hr.	[illegible]
Other men at 2[illegible] cts. per hr.	[illegible]
Water boy at 1[illegible] cts. per hr.	[illegible]
Foreman at [illegible] cts. per hr.	[illegible]
Total labor	[illegible]
[illegible] bbl. cement at $[illegible]	[illegible]
[illegible] ton sand at $[illegible]	[illegible]
Grand total	[illegible]

On the [illegible] sq. yd. job the labor of grouting was only [illegible] ct. per sq. yd.

The cost of the expansion joints [illegible] along each curb was as follows per sq. yd. of pavement:

	Per sq. yd. cts.
Labor at 2[illegible] cts. per hr.	[illegible]
Pitch at $[illegible] per bbl.	[illegible]
Total	[illegible]

Summing up, we have:

	Per sq. yd.
Concrete labor	$[illegible]
Concrete materials (see text)	[illegible]
[illegible]	[illegible]
Brick and sand cushion	[illegible]
Grout labor	[illegible]
Grout materials	[illegible]
Expansion joints, labor and materials	[illegible]
Grand total	$[illegible]

The cement curb [illegible] 1 [illegible] Storm sewer. The average cost of the three jobs, A, B and C, reduced to the same rates of wages is given below. Job A was [illegible] lin. ft., B was [illegible] lin. ft., C was [illegible] lin. ft. The curb [illegible] was backed with cinders as shown in the accompanying illustration. The following costs are in cts. per lin. ft.:

	A	B	C
Trenchmen, [illegible] per hr.	[illegible]	[illegible]	[illegible]
Form setters, [illegible] per hr.	[illegible]	[illegible]	[illegible]
Filling cinders, [illegible] per hr.	[illegible]	[illegible]	[illegible]
Wheelers, [illegible] per hr.	[illegible]	[illegible]	[illegible]
[illegible] per hr.			[illegible]
[illegible] per hr.	[illegible]	[illegible]	[illegible]
[illegible] per hr.	[illegible]	[illegible]	[illegible]
Men at mixer, [illegible] per hr.	[illegible]	[illegible]	[illegible]
[illegible] per hr.	[illegible]	[illegible]	[illegible]
[illegible] per hr.	[illegible]	[illegible]	[illegible]
Miscellaneous, [illegible] per hr.	[illegible]	[illegible]	[illegible]
Water boy, [illegible] per hr.	[illegible]	[illegible]	[illegible]
Team and driver, [illegible] per hr.	[illegible]	[illegible]	[illegible]
[illegible] engine, [illegible] per hr.			[illegible]
Foreman, [illegible] per hr.	[illegible]	[illegible]	[illegible]
Total labor	[illegible]	[illegible]	[illegible]
	A	B	C
Cement at $1.[illegible] bbl.	[illegible]	[illegible]	[illegible]
Sand at $1.[illegible] ton	[illegible]	[illegible]	[illegible]
Cinders	[illegible]	[illegible]	[illegible]
Total materials	[illegible]	[illegible]	[illegible]
Grand total	[illegible]	[illegible]	[illegible]

Since it takes [illegible] lin. ft. of [illegible] to make 1 cu. yd., the [illegible] must be multiplied by [illegible] to reduce to a cubic yard basis. [illegible] the labor [illegible] and placing concrete, [illegible] the labor on job C was 7.1 cts. per lin. ft., which is equivalent to $[illegible] per cu. yd. of cement curb. The other [illegible] pensive, particularly in the items trenching and teaming. None of the three was economically handled, as may be seen by comparison with the costs given on p. 180 et seq. of Gillette's "Handbook of Cost Data," where the labor cost about half as much per cubic yard as on Job C, and far less than half as much as on Jobs A and B.

Curbs often differ considerably in cross-section, and the labor of mixing and placing the concrete therefore differs materially when compared in terms of the lineal foot as the unit. Hence all costs should also be reduced to the cubic yard basis also. When this is done, a contractor will frequently find that his work is not being handled with the expedition that it should be; for comparison with the cubic yard cost of other jobs of similar character may disclose to the contractor a weakness of management or laziness of men on his own job.

Wear and Tear of Motor Traffic on Roads.*

BY W. J. TAYLOR,† M.INST.C.E.

The introduction and expansion of high-speed self-propelled traffic, which we have witnessed during the past thirteen years, has made it incumbent upon those who are responsible for the upkeep of roads to carefully watch and study its effect on them, as compared with the wear and tear of the older and slower moving forms of traffic, which now bid fair to vanish from our roads almost entirely. The almost unanimous verdict is that the wear and tear is very greatly increased by the faster moving traffic, and, at any rate, for a time, a check has been given to the renaissance of our main roads which was going on throughout the kingdom. The expansion of ordinary traffic, the growth in the number of traction engines, and, lastly and principally, this rising tide of automobilism, has had a marked effect on the annual cost of maintenance of our roads.

The following is a comparative statement of the annual outlay on maintenance and repair of the main roads in England and Wales during the past nine years:

Year ended March 31.	Mileage.	Total cost.	Rate per mile.
1901	26,598	£2,024,711	£76.1
1904	27,223	2,366,163	86.9
1905	27,367	2,406,754	87.9
1906	27,380	2,478,481	90.7
1907	27,556	2,529,137	91.8
1908*	27,600	2,644,718	95.4
1909‡	27,600	2,766,903	100.2

*Partly estimated.
‡Estimated.

In this respect, however, we appear to be on the threshold of events only, as a very large proportion of our roads bear upon their surfaces eloquent records of the effects of high-speed traffic, and call for far greater outlays to fit them for modern forms of traffic.

Although the increase in cost has been general, the heaviest burden has probably fallen on the southeastern half of England, in which portion about 56 per cent of the whole of the motor-cars in the United Kingdom are registered, and, in addition to the great trunk arteries of traffic from the metropolis radiating through it, we have to bear in mind that there are no local supplies of hard road stone which are capable of offering any effective resistance to the wear and tear of even ordinary traffic beyond that of a light character.

In dealing with this question of wear and tear of motor traffic, the writer offers no apology for considering its effects on poor roads repaired with local material, as this is the condition of affairs in a very large proportion of the mileage of even our main roads, and if there were no weak roads the deliberations of this conference would possibly not be necessary.

The writer's experience of the effects of high-speed traffic on long mileages of rural main roads has been that it hastens the deterioration of the surface in some respects more rapidly than can be accounted for by a mere increase in the number of journeys made.

On well-made basalt surfaces where large gage stone is used, the effect of unarmoured pneumatic tires (except where the traffic is concentrated in one track) has probably not been so destructive as ordinary iron tires, the area of contact in the former case being greater, but on roads repaired with flint and gravel the reverse has been the case, the finer particles have been drawn from the interstices of the stones, thus unkeying them, and the loosened material is crushed by all kinds of traffic, and there has been much loss.

It is, however, against the armoured tires that our most serious charge is levelled, and complaint is widespread of the damage caused by studded and other forms of armored tire on all kinds of roads.

Injury is inflicted by the studded tire in several different ways; in the turning movement the loosening effect of the studs is very noticeable; again, by reason of the small area of the iron studs through which the load is transmitted to the road surface, defects in contact appear to be intensified, and the rolling effort has a greater disturbing effect on the macadam. On account of the leaping or galloping motion acquired by cars running at a high speed, contact with the road surface is more or less intermittent, and the vehicle proceeds with a series of impacts, when the steel studs are not only destructive by reason of the shocks with which the small area of metal points is brought down on the road surface, but they corrugate it by kicking out the material. When the wheels, which are the medium of propulsion, leave the ground, they revolve at a greatly increased velocity, and when they again come down it is the road surface which has to do the work of reducing this revolving file to the speed of the car, with the result that portions are worn out of the road in its resistance to this tangential force; and many lengths of our roads repaired with all kinds of metal bear witness of this by the long lines of depressions and corrugations in their surfaces.

Another potent cause of damage to road surfaces is the wheel of small diameter which the makers of cars, especially those of the heavy type, have adopted. The well-known experiments of Morin early in the last century, and of those other investigators who have followed him, have, unfortunately, for some reason, not been followed. It is so well known how the rolling resistance is reduced as the diameter of the wheel is increased, and that passing over unevennesses in the surface is accompanied by less shock with large than with small wheels, with consequent saving both to road and vehicle, that it is specially unfortunate that car designers have not been able to help the road problem in this direction, more especially when it is borne in mind that the limit of usefulness in merely broadening tires is soon reached, as on a portion of its width only can a cylindrical tire bear on a cambered surface, whereas by increasing the diameter the tread may safely be reduced in width. Roads under the writer's control have suffered very serious damage by the action of the small wheel. It sinks into the surface and imparts a wave motion to it by the forward or pushing effort, and the crust is disturbed, water admitted into the road, and the material loosened and lost by rubbing, attrition, and displacement.

These influences of the motor, making for the destruction of the road, are, however, greatly intensified and the cost of coping with them augmented when the traffic persists in holding to the center of the road. It is the tendency of all vehicles to keep to the center of the road, where the traffic is not sufficient to compel them to continually break track, and no doubt defects in the road have in places largely contributed to this center tracking, but even where the sides are strengthened and the cross-fall reduced to a maximum of 1 in 24 it is most difficult to induce traffic to distribute the load, and so evenly and uniformly wear down and reduce the whole surface from margin to margin, thus enabling the engineer to avoid those costly and unsatisfactory patchings and repairs in detail. The combined effects of small and armored wheels continually traveling in one track is to depress, groove, and often to cut through and destroy the surface of the road, no matter what material it may be made of; and it is a curious fact that it should be left to automobilism (to which good roads are so essential) to put upon the road surface the most destructive and, from the point of view of economical rolling contact, the most unscientific wheel that has ever been devised.

With the object of better fitting the main roads to carry the increasing traffic, most of the road authorities have for many years set themselves the task of abolishing the use of soft road materials, such as limestone, flint and gravel, and using in their place hard stones, such as granite and basalt, and they have made and compared innumerable experiments to ascertain the stones most suitable to the varying local conditions of climate and subsoil. This work, which must be accelerated under new conditions, will, however, take a long time to accomplish, as the cost of laying down a 3-in. consolidated coat of granite on those 4,500 miles of main roads alone in the southeastern half of England, which are yet repaired with local stone, will be about £5,000,000.

Good work is also being done in strengthening the road surfaces, which are now in many places mostly very thin and insufficiently supported on yielding foundation, or are without any foundation at all. This also is a work of great magnitude, and must necessarily occupy a considerable period. It is hopeless to think that substantial foundations can be built into our roads—except in special cases—as the initial outlay is so great and the improvement so local; the work will almost entirely be effected by dealing with the whole area of surface at once—that is, by gradually thickening the road crust, by laying down over the whole area of the roads a little more material each time they are repaired than has been worn out, and so accumulate a more substantial road crust. But even this will cost many millions for each inch of added thickness to the road surface.

If, in addition, we can use bituminous coats and matrix, we may hope to resist undue wear and satisfactorily provide for —as far as that is possible—the demands of all forms of traffic, but it is very difficult to see how the funds necessary to accomplish this work are to be raised.

It will at any rate facilitate and hasten the coming of the perfect road if those responsible for the design and use of the motor will give the road engineer their active co-operation.

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†County Surveyor, Hampshire.

*Paper read at the recent Road Conference, convened by the County Councils Association of Great Britain at the Institution of Civil Engineers, April 24-May 2, 1909.

Unclassified and General Articles

Note: This section is devoted to methods and cost articles on construction work not properly coming under any of the preceding classifications.

Average Cost of Cross Ties in the United States in 1907 and 1908.

The advance statement relative to the consumption or purchase of cross ties in the United States during 1908 has recently been issued by the U. S. Bureau of Census. The accompanying tabulation shows the totals and average cost of the various kinds of cross ties purchased by steam and electric railroads during the calendar years 1907 and 1908.

As indicated by the figures there was a marked falling off in cross tie purchases by the steam and electric railroads of the country during the calendar year 1908, as compared with 1907. A significant feature of the showing is the fact that in 1908 only 7,131,170 cross ties were reported as purchased for new track, as against 23,557,000 in 1907. Purchases by steam railroads formed substantially the same proportion of the total in both years approximately 91 per cent.

TOTALS AND AVERAGE COST OF CROSSTIES IN 1907 AND 1908

Kind of wood	1908 Number	1908 Cost at point of purchase	1908 Av. cost per tie	1907 Number	1907 Cost at point of purchase	1907 Av. cost per tie
Oaks	48,110,853	$24,653,042	.512	61,757,418	$32,[illegible],122	[illegible]
Southern pines	21,528,874	11,598,896	[illegible]	34,215,081	18,434,198	[illegible]
Cedar	8,171,492	4,028,323	.493	8,953,295	4,473,[illegible]	[illegible]
Chestnut	8,073,685	3,980,744	[illegible]	7,851,325	3,772,018	[illegible]
Douglas fir	7,586,950	3,598,856	[illegible]	14,524,266	6,818,[illegible]	[illegible]
Tamarack	4,024,919	2,020,169	.502	4,762,190	[illegible]	[illegible]
Cypress	3,456,702	1,519,326	[illegible]	6,778,944	3,[illegible]	.442
Hemlock	3,120,000	1,178,996	.378	2,366,459	[illegible]	[illegible]
Western pine	3,092,943	1,573,608	.508	5,019,247	[illegible]	[illegible]
Redwood	871,906	443,066	.508	[illegible]	[illegible]	[illegible]
White pine	706,861	335,724	.460	474,455	[illegible]	[illegible]
Lodgepole pine	517,109	246,299	.476	666,916	332,[illegible]	[illegible]
Gum	261,551	116,631	.446	15,124	[illegible]	[illegible]
Beech	192,848	85,447	.443	51,199	[illegible]	[illegible]
Spruce	140,687	66,619	[illegible]	[illegible]	[illegible]	[illegible]
All other	[illegible]	835,472	[illegible]	[illegible]29,131	[illegible]	[illegible]
Total	112,463,449	$56,280,568	$0.501	[illegible]	[illegible]	$0.[illegible]

Cost of a Semi-Circular Brick Culvert.

The culvert was built at Columbus, Miss., during the month of May of this year. It was built at the intersection of two streets and takes the place of two wooden bridges. The dimensions of the culvert were as follows: Cross-section, inside measure, diameter, 6.5 ft.; length on center line, including end walls, 39.8 ft.; radius of arc of center line, [illegible] ft.; length of arc, one-fourth circle; thickness of arch (2 rings), 9 ins. The two end walls were each 8½ ins. x 5 ft. x 12 ft. The floor of the culvert was one brick thick, on edge, laid in ¼ in. of cement and grouted. The floor was 8 ft. wide and 10 ft. long. The cost of the culvert was as follows:

Materials	Total	Per lin. ft.
Lumber for arch forms	$ [illegible]	$ [illegible]
Nails	[illegible]	[illegible]
Sand (5¼ yds., 7 loads at $[illegible])	[illegible]	[illegible]
Brick, 8,500, at $6.50 per M delivered	[illegible]	[illegible]
Cement, 16 sacks, at $1.60 per bbl. delivered	[illegible]	[illegible]
Kerosene oil for lights	[illegible]	[illegible]
Total	$ [illegible]	$ [illegible]
Labor		
Drayage	$ 1.00	$ .025
2 bricklayers, 57½ hrs. at $0.50	[illegible]	[illegible]
3 laborers, 116 hrs. at $0.10	11.60	.291
Carpenter, making arch forms	[illegible]	.063
	$ [illegible]	$1.[illegible]
Grand total	$12[illegible]	$[illegible]

As there were approximately [illegible] of brickwork the cost per cubic yard was about $6.03.

The engineer's estimate of cost was $128, and he took the job for $112. His profit, therefore, was $[illegible], or [illegible] per cent on the cost. For the above information we are indebted to Charles [illegible] Wood, C. E.

Methods of Making Test Borings for the Katskill Reservoirs for the New York Water Supply With Some Plant Costs.*

Borings were carried on partly by day labor employed directly by the Board and partly by contract. The scarcity of experienced drill-runners was felt at the start and the deficiency met by training the men who showed ability in that direction. The drill crews for the machines of the contractor consisted of a drill runner of three or more years' experience and a skilled helper. Several additional men were employed in connection with the operation of a group of drills, one at the pumping station, another setting diamonds and others for general work. In the work of the Board of Water Supply three men were used on each drill.

The boring equipments of the two organizations were somewhat different. [illegible]

[illegible]

Total [illegible]

[illegible]

Protection from the weather during the winter work was obtained by the contractor by wooden shanties erected at each boring. [illegible]

In connection with the drilling operations by the Board portable buildings were used for blacksmiths' [illegible] office, etc. They proved very satisfactory and were easily moved from one location to another. The sections are so designed that they may be readily carried on a farmer's wagon and require only two men for handling. A bill of materials is given below:

[illegible]

[illegible]

*Extracted from a paper by J. S. [illegible] read before the Brooklyn Engineers' Club, Jan. [illegible] ward course, loosening the material which comes up with the water between the wash pipe and casing. See Fig. 1. When a sufficient depth is washed out below the casing the rope is transferred from the water swivel to the hollow drive weight which surrounds the casing and acts on the drive head. The swivel and wash rods may remain in place, the casing being driven down while twisted with a downward pressure. In addition to twisting the casing, which was found to greatly lessen the adhesion, the casing was "flooded," *i. e.*, water under high pressure was forced through the casing so that its only escape was beneath and up around the outside of the surface. This twisting and flooding of the casing kept it loose and minimized breaking or bending.

Dynamite was frequently used in hardpan or where boulders were numerous. The casing was raised about 6 ft., a properly prepared charge lowered to the bottom of the boring and the explosive discharged. The casing would then be redriven and the washing proceed as before. When a large boulder was encountered, it was drilled with a diamond bit, shattered with dynamite and the casing driven through the opening thus formed. In sand or similar loose material, the best results were obtained by continual "flooding," which caused the casing to settle of its own weight.

In the wash borings made under contract somewhat different methods were employed. Extra heavy coupled casing was used, 4-in. for the first 20 ft., 3-in. telescoped inside the above for the next 50 or 100 ft., and, if necessary, 1½ in. inside the latter for holes of greater depth. Water was delivered in a similar manner to that used for the rigs of the Board. A temporary platform, derrick and shanty, were erected before beginning operations. In these borings the water was passed through the rubber hose and water swivel into the wash pipe, which was twisted by one man, while the other with a couple of turns of the rope around the drum of the machine, raised and lowered the wash rods. When a sufficient depth was washed ahead of the casing, the rope was detached from the wash pipe and attached to a 450-lb. oak "drive block." An iron "drive head" was placed on top of the casing before beginning to drive. When holes were driven to great depths in hardpan or other material that would stand up for 10 ft. or more, the "A" bit, giving a 1¾ in. diameter core, was used to advantage. A 1½-in. casing could be placed in the hole thus made without any chopping. In one case the diamond bit passed through hardpan for 60 ft. and following this, through 30 ft. of fine sand and clay. After the drill rods had been withdrawn and replaced at least twelve times during the drilling operation, 30 ft. in rock was drilled below this 90-ft. section containing no casing, without any mishaps.

Diamond Drill Borings.—When bed-rock was reached, the casing was well "seated," and the screw feed attached to the drill. The diamond bit with core shell and core lifter were adjusted to the core barrel. These were placed in the hole and a sufficient number of hollow drill rods attached to bring the bit in contact with rock; 10 or 15 ft. of rods at the upper end were placed through the hollow drill spindle of the screw feed, screwed to the rods in the hole, and clamped.

The operation of drilling consists in giving a rotary motion to the drill rods with attached core barrel and diamond bit. The core barrel is generally 5 or 10 ft. long and of slightly larger inside diameter than the resulting core, enabling water to reach the bit. On the outside of the bit are water grooves, allowing the water with the rock cuttings to escape up around the diamond bit between the rods and casing to the surface. Between the diamond bit and the core barrel in the core shell is a "core lifter." This device is a split ring through which the core must pass before entering the core barrel. The latter retains the core when the rods are pulled up, due to the reduction in diameter produced by the downward pressure of the core. A drill runner, in order to be sure that the core is in the barrel, will "block" the bit, *i. e.*, he will break off the core so that it will enter the core barrel and so exert a downward pressure on the core lifter. This is accomplished by running the machine at its full capacity until it suddenly stops or "plugs"; or the flow of water may be stopped and the core broken by the heat generated by the diamond bit. The choice of method used depends upon the character of the rock encountered. In very soft rock it is next to impossible to make large runs without "blocking." In this event the rods must be pulled up frequently and the core removed in order that the drilling may proceed. The size of bit used varied with the casing. With the larger casing an A bit giving a core 1⅛ ins. in diameter, was used, but when the 1⅝-in casing was employed, the E bit giving a 15-16-in. core was required.

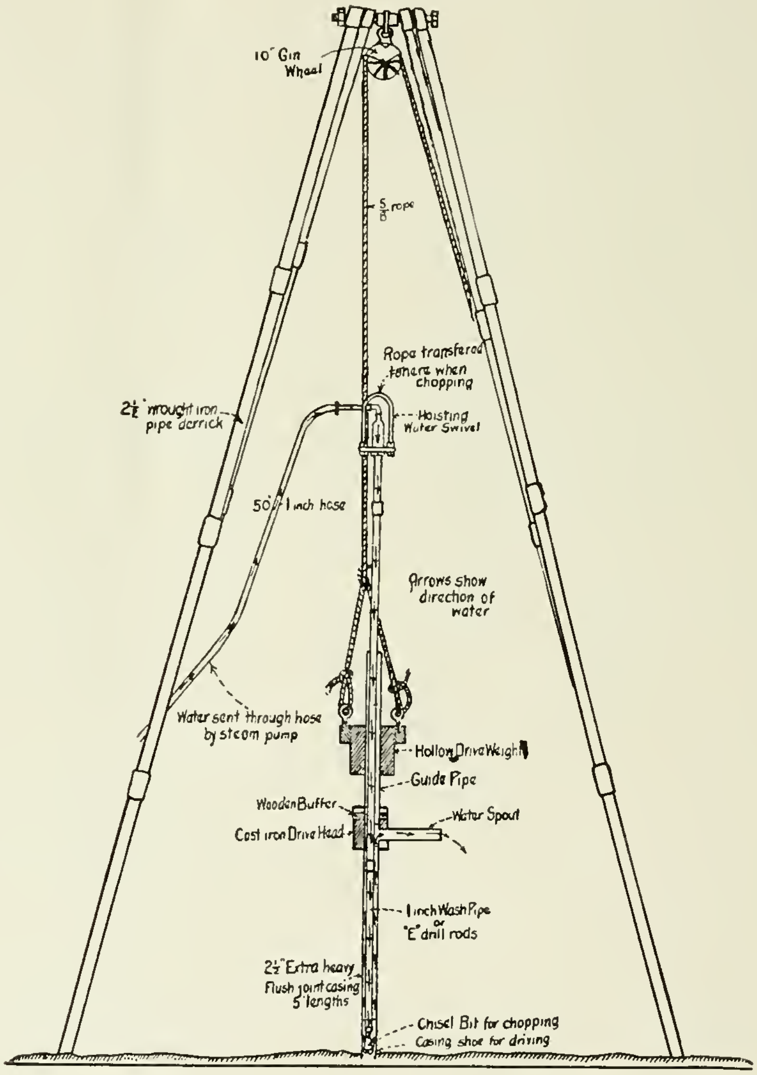

10" Gin Wheel
⅝ rope
Rope transfered to here when chopping
Hoisting Water Swivel
2½" wrought iron pipe derrick
50' 1 inch hose
Arrows show direction of water
Water sent through hose by steam pump
Hollow Drive Weight
Guide Pipe
Wooden Buffer
Water Spout
Cast iron Drive Head
1 inch Wash Pipe or "E" drill rods
2½" Extra heavy Flush joint casing 5' lengths
Chisel Bit for chopping
Casing shoe for driving

Fig. 1. Outfit for Making Wash Borings.

Owing to the lack of experienced drill runners, the screw feed only was used on the machines operated by the Board. After a man has worked for six months on one of these rigs, he should be competent to run the drill. With the screw feed there is a positive rate of advance, *i. e.*, it requires so many revolutions of the rods to advance a certain distance, irrespective of the quality of the rock. When an open seam was encountered, the machine would "race" until rock was again reached. Where greater progress was desired in the rock, the steam was increased, resulting in a greater number of revolutions per minute of the bit. On the counter-shaft was a friction device which allowed reversal of the feed and acted as a safeguard against any sudden jar to the diamond bit.

Hydraulic feed was used on the machines employed by the contractor. The amount of water admitted or released from the hydraulic cylinder is fully controlled by adjusting the valves, thus giving an unlimited range of feed, which is of great value to an experienced drill runner. The hydraulic feed apparatus is entirely independent of the engine, and the feed may be regulated or reversed while the rods are still rotating. In this way the feed may be adjusted to take advantage of the slightest change in the character of the rock. In soft rock a greater downward pressure is possible, while in hard rock the feed is diminished, thereby increasing the number of revolutions per inch of advance. In this manner a constant pressure may be kept on the diamond bit.

The methods used in setting diamonds

were practically the same in the operations of the Board and of the contractors. Eight diamonds were placed in a bit, four on the outside and four on the inside cutting edge of the annular ring. Blank bits of special soft Swedish iron, made to gage measure, were furnished by the manufacturers. A clearance of 1-64 to 1-32 in. on each stone, depending on the nature of the rock to be drilled, was allowed in setting the diamonds. In soft rock a greater clearance was necessary in order to prevent the drill cuttings from plugging the bit.

Comparison of Methods.—(a.) Rigs.—A great advantage in moving from one location to another and setting up appeared in favor of the light rigs used by the Board. Where it took the contractor's rigs an entire day to change location, under similar conditions the rigs of the Board would be prepared for operation in about one or two hours. On one occasion under exactly the same conditions, the Board's rig had moved, finished a 30 ft. hole and set up at another location in the time it took the contractor's rig to move and start the first hole. The contractor's machines, however, were much more powerful, and on deep holes the time of moving and setting up would be equalized. For holes up to 100 ft. in depth the Board's rig appeared to be the better; while for holes of greater depth the machines of the contractor proved better adapted for the work.

(b.) Casing.—The method of driving the casing employed by forces of the Board resulted in fewer accidents, such as bending, twisting or breaking, and a larger proportion of the casing could be taken out and used again than was the case in the operations of the contractor. This was due to using flush joint casing and twisting and "flooding" it down rather than relying wholly upon forcing it down with the drive weight. The contractor's scheme of telescoping 1½-in. and 3-in. casing inside the 4-in. casing produced excellent results.

A great advantage in speed was gained in using the X bit and lowering the 1½-in. casing into the hole thus formed. When this method was used, however, the information regarding the character of the material penetrated was more or less uncertain, and it is not recommended when accurate information with reference to the character of the material is desired.

(c.) Drilling in Rock.—For drilling in rock the machines used by the contractor proved better adapted where progress was the essential point. These machines, equipped with the hydraulic feed, would make 40 ft. a day in good bluestone, while with the screw feed the machines of the Board were limited to 30 ft. An important consideration acting, under the circumstances, in favor of the Board's machines was the relative degree of skill required to operate the two types. The contractor did not deem it expedient to place a man with less than three years' experience in charge of a drill. On the other hand, men were used successfully on the Board's machines with but six months' previous training.

Inspection.—One man was able to take care of four rigs or two test pits and take ground water observations. He took samples on holes in progress, made observations on completed holes, assisted in locating holes and made monthly estimates on test pits. A single rig was used to travel from one boring to another when they were at some distance, and also to carry core boxes, samples, bottles, marking boards, etc.

Dry sand wash samples were placed in small bottles, corked and carefully labeled. These were placed in drawers which were systematically arranged and so conducted that the samples from any hole could be readily found.

Upon being removed from the core barrel of the boring machines all cores were stored in core boxes. Each box contained room for four rows of core in the bottom of the box together with trays capable of three rows each. A box would hold about 35 ft. of core which generally represents about 50 ft. of actual drilling.

The core was labeled, boxed and stored in a small portable building shelved on all sides, where the core boxes were properly painted with number and depth of hole. Here they were readily available for future inspection. In addition to the core boxes, cabinets containing drawers were provided for filing the samples.

A daily report was made by the foreman of each gang on the form shown by Fig. 2.

Instructions to Inspectors of Borings.—A copy of the following instructions was given to each inspector for his guidance:

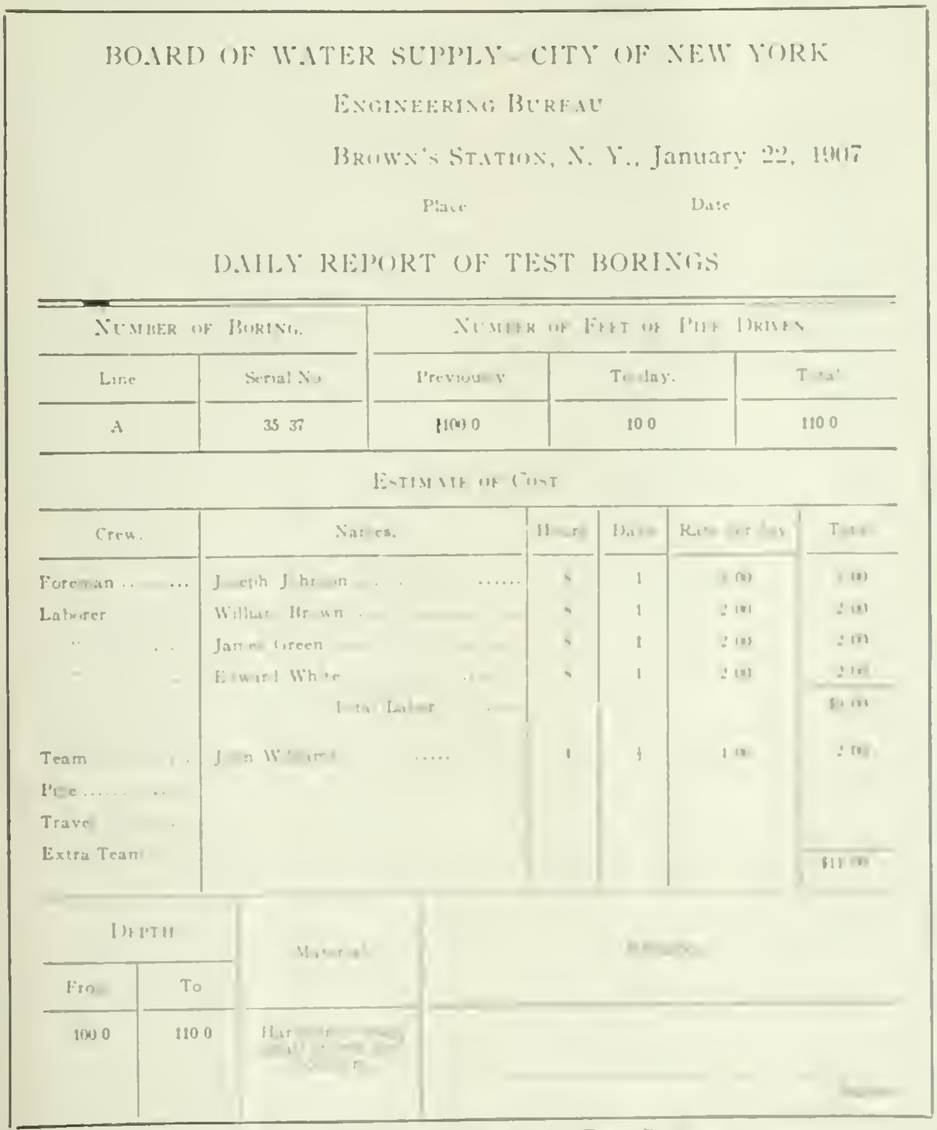
These borings and test pits are being made to ascertain the character of the overlying material, the elevation of bedrock, the quality of this rock and incidentally all data that would aid in the selection of the best dam site.

In order to get an accurate determination of these conditions much depends upon the faithfulness and good judgment of the observer. His interpretation of the material must be based on the samples taken and careful observation of the mechanical operations of the machines and the wash which comes up through the casing. The following are some of the general rules which the inspector should be careful to note:

1. Observe very carefully the character of the material washed up and the color of the escaping water. Upon the proper interpretation of the above depends very much the value of the test hole, for, no matter how good or how accurate the samples may be, the true nature of the ground is best obtained by observing the mechanical operations in field. For instance, the wash may be clayey while the sample will contain no trace of clay, but the observer should record clay present as shown from the discoloration of the escaping water.

2. Take a sample for every 10 ft. driven and, if the material changes rapidly, a sample should be taken at every marked change. Should less than 10 ft. be made in a day, one sample will then be sufficient. There are two methods of taking samples of materials: A, the dry method; B, the wash method.

A. The dry method is by far the more satisfactory when very accurate results are required. It is, however, an expensive and tedious method of procuring results. A 1¼-in. perforated wrought iron pipe is driven into the material below the casing



BOARD OF WATER SUPPLY—CITY OF NEW YORK

ENGINEERING BUREAU

BROWN'S STATION, N. Y., January 22, 1907

Place Date

DAILY REPORT OF TEST BORINGS

Number of Boring.		Number of Feet of Pipe Driven		
Line	Serial No.	Previously	To-day.	Total
A	35 37	100 0	10 0	110 0

ESTIMATE OF COST

Crew.	Names.	Hours	Days	Rate per day	Total
Foreman	Joseph Johnson	8	1	3 00	3 00
Laborer	William Brown	8	1	2 00	2 00
"	James Green	8	1	2 00	2 00
"	Edward White	8	1	2 00	2 00
	Total Labor				$9 00
Team	John Williams	1	½	4 00	2 00
Pipe					
Travel					
Extra Team					
					$11 00

Depth		Material	Remarks
From	To		
100 0	110 0	Hard [illegible]	

Inspector

Fig. 2. Daily Report Blank for Test Borings

The pipe has holes in it so that the water may be easily displaced when the sample of compact material enters the bottom of the pipe. For sand or material which would fall out of the sample pipe on being lifted, a "sand spoon" is used, a pipe with a closed pointed end, with a slit or opening about 1 ft. from the point. This is driven into the material, and, on pulling it up, the sand enters the spoon and is so brought to the surface. In this way the material is obtained just as it exists.

B, the *wash method,* is as follows: In a tub or a half-barrel with a glass panel in one side, the wash, which comes up through the casing, is allowed to flow. If conditions are right and the tub becomes full, it is placed at one side and about a teaspoonful of hydrochloric acid mixed with water. The action of the hydrochloric acid is very decided. It takes about 30 minutes to settle, while with no acid, it would take half a day. The settlement of the material may be seen through the glass panel. When settled, siphon off the clear water and the washed sample remains. Fill a sample bottle with the material, label with date, depth of hole and description of material.

Take dry samples, owing to their expense, only of material which may be regarded as porous, *i. e.,* sand and gravel, sand, or sand with a little clay; otherwise the wash sample, combined with the proper observations, will serve all general purposes. Never take a sample directly after a blast, nor when the wash pipe is too far ahead of the casing. The best time is when the wash pipe is about 3 in. ahead.

3. make a concise record of the action of water in all boring operations. Should the water forced down the wash pipe fail to come to the surface again, it should be recorded as "losing water." This would signify that the material is water bearing or porous, or it may be a seam or cavity such as may exist in rock. Should the water stay at the top of the pipe it would show the impervious nature of the underlying material. The water may flow out of the top of the casing, indicating that a stream of water has been encountered with a greater head than that in the pipe.

4. It will not be sufficient to report a material as "clay and sand," for clay and sand in different proportions and under different conditions may vary from a very soft material to hardpan. They may be stratified or exist as separate pockets or closely intermingled, and all these conditions may be upset when water is present. A proper description should read as follows:

From 90 to 100 ft.—Hardpan, *i. e.,* clay, small stones and boulders in a very compact mass. Must use dynamite almost constantly in order to make any progress.

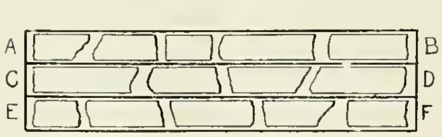
From 100 to 140 ft.—Clay and sand Material very soft, the weight of rods being sufficient to penetrate the material which stands up well and does not fill in when casing is removed.

5. The inspector must bear in mind the possibility of large boulders existing, and should constantly be on the lookout for indications of them in the drilling.

NOTE: In this locality boulders greater than 20 ft. in any dimension were not met with, but some were found that were 10 or 12 ft. through. Consequently, when bedrock was reached, it was decided to drill 20 ft. to make certain it was not a boulder.

6. Core should be placed in the bottom of core box, as shown in sketch, as soon as it is obtained. At *A* place the top piece of core, labeled with hole number and depth. Then place the remainder consecutively as shown: The core at *C* follows that at *B*, while that at *E* follows *D*. The next layer is filled with core in the same manner. The core placed corresponding to *A* will follow core at *F*. After the box is filled, it should be nailed up at once for storing. In every case, all pieces of core, obtained from boulders and not properly relating to the hole in question, should be gathered up and placed in a box made for that purpose.

7. Record all seams encountered in rock. If the machine "races" while drilling with screw feed, it is probably in a seam and the depth should be recorded with width of seam. This may be obtained by measuring to the depth at which the drill stops "racing." With the hydraulic feed, an experienced drill runner will put more pressure on the rods so that the machine will not "race," and he will be able to tell you whether it was a seam or soft rock. These data should be checked with the core when it is taken out. Should a seam be encountered, with a loss of water for some time, it would show an open seam of considerable extent and perhaps finally emptying into some waterway. Should the water be lost for a short time only, it would signify a slight cavity in the rock, or a small seam which was made watertight by the rock cuttings in the wash. After the water has been entirely lost, another open seam may be encountered with no surface indications of a loss of water; hence the best expedient is to fill the upper seam by forcing oats through the wash pipe with the water. This will plug the seam and the water will be regained. The core is obtained in pieces, varying from a few inches to several feet in length. Note by inspection whether these pieces are broken off mechanically or whether seams exist.



8. Record the length of core obtained with the amount of the corresponding run and any conditions which may affect this amount. A strong pressure of water has enough force to loosen a soft rock so that it will come up with the wash and leave no core. With the hydraulic feed the runner will be able to make much more progress with a smaller percentage of core. He will use a full pressure of water down the wash pipe and a heavy pressure on the hydraulic feed, grinding to pieces the core of a fairly good rock. Sometimes core will be left in the hole when withdrawing the core barrel. This may be discovered by dropping a weighted tape down the hole and noting the depth. Core, so left, may be recovered by replacing the bit and drilling a little farther.

9. After a hole is finished the inspector should measure it carefully. A general impression of the hole should be sent in on the daily report, obtained from interviews with the drill runner and from the inspector's own observations. It should state, in a general way, the character of the material penetrated and might read as follows: "The material in this hole was very compact and tough, with the exception of a strip between 30 to 40 ft. deep, in which clay for the most part was encountered, the rods and casing going down very readily. The rock was soft for the first 5 ft. but then became very hard. This hole might be compared with *C* 16/18 as previously reported."

10. The casing, or some smaller pipe, may be left in the hole after a boring is completed, so that observations to determine the ground-water level may be taken. These observations should be sent in on the daily report, giving the depth from the surface of the ground to water in the pipe. A small brass weight with a cup-shaped cavity in the bottom is very useful for this purpose and may be attached to a steel tape.

11. Upon the completion of a boring, a board should be placed by it showing its number, depth, elevations, etc. These should be attached to a tree, a stout post or a stake.

12. Make your daily report on form 111 E and had it in promptly each night.

Test-pits and trenches are made to obtain a more accurate idea of the material than is procured by borings, and also to check them.

Consequently in the report of materials more detail should be given. The following are some general rules to be observed.

13. The material should be described as to: (a) composition (proportion, if possible), (*b*) how compact it is, (*c*) for what height, if any, it will stand up before lagging is put in place, and (*d*) what effect water has on the material.

14. The trenches are placed in side hills, step-like fashion. A report should be sent in when the trench is completed, describing the material, minutely referring to the stationing on the stakes along the trench. Note the action of any water present and send in a force account when the trench is completed.

15. Small test-holes, similar to post holes, should be placed in the steps when the trench is finished and filled with water. Take observations on them hourly, to test porosity of the soil.

16. On the test-pits, a report should be sent in daily. Successive photographs should be taken as the work proceeds, in order to convey an accurate impression of the materials as they actually exist and to check observations and reports. These may be taken so as to show the entire shaft in panorama shape and should be accompanied by a description of the material.

17. Estimates, showing in detail the amount of excavations, timbering, etc., should be made on the first day of each month.

Conclusions.—The experience gained in the borings at the Ashokan Reservoir led to the following conclusions:

1. A washed sample without proper observations was of no value as a record, while greater weight given to the inspection of the boring operations would approach the actual conditions much nearer.

2. A dry sample was more satisfactory, but, without the inspector's observations, was not sufficient.

3. Invariably the proportion of clay given in boring records was too small.

4. The coarser materials, such as boulders, cobbles, etc., were not given enough weight.

5. Small stones would be chopped up by the bit and on coming up through the casing would be interpreted as sand.

6. If water was lost it was in a pervious material or water-bearing stratum with little or no clay present, or a seam in rock.

7. If material was recorded as "sand and gravel" with no loss of water, it was probably an incorrect record, for clay generally was present.

8. The percentage of core obtained, everything else being equal, varied directly with the hardness of the rock.

9. A larger percentage of core was possible with a bit of large diameter.

10. The conglomerates and harder sandstones yield nearly 95%, while the softer, loose and tilted shales yield less than 25% of core at best.

11. A good hard rock suitable for foundation or construction may be granular or nodular in texture and consequently give very little core and that very seamy. This core would be recorded as seamy and would

give a false impression of actual characteristics.

12. The amount of core should be but a small factor in a general determination of the quality of the rock. The improper setting of a bit, excessive vibration of the rods, too strong a force of water, or the grinding away of the core, will reduce the amount obtained.

13. Vertical seams will reduce the amount of core. One case is worthy of mention: Ten feet had been drilled and the working of the machine showed no unusual conditions. On pulling up the core barrel, it was found that only 1 ft. of core had been obtained. A weighted tape was dropped into the hole to see whether any core was left, but the hole was found clear and empty. By careful inspection of the core that was obtained, the presence of a vertical seam was discovered. The machine showed no indications of soft rock or horizontal seams in the running, the wash came up throughout the run with good bluestone cuttings. It was concluded, therefore, that the bit had been in a vertical seam and was cutting good rock with its outside diamonds and consequently no core was made and a report to that effect was sent to the office.

14. It is possible from inspection to see whether detached pieces of core are broken mechanically or whether seams exist.

15. Boulders greater than 12 ft. in vertical dimensions were not encountered in the glacial till of this section.

Pressure Tests of Bore Holes.—Before beginning excavations for the foundation of the Olive Bridge Dam, a careful study was made of the rock to a depth of 100 ft. below the creek bed. The purpose of the study was to investigate the rock for possible cavities or openings, and to discover and definitely locate any seams that might exist. To this end fifteen diamond drill borings were made, with a total length of 1,300 lin. ft.

Care was taken to accurately locate the position and width of all seams or soft spots encountered during the progress of a bore. The drills were equipped with a screw feed, which insured a uniform rate of progress for a constant number of revolutions per minute. Thus in sound rock the drill ran regularly, but as soon as the bit broke through into a softer layer or into a seam, the load was released from the engine and the latter raced. This racing continued until the screw feed had carried the bit down to harder rock or until it struck the lower side of the seam encountered. As soon as such a racing occurred the engine was stopped, the depth of the bottom of the bore noted and a mark placed on the drill rods. The set screws holding the rods were then carefully loosened and any drop of the rods noted. The rods were then slowly turned by hand to work them through any soft filling of mud or clay that might be in the seam. If no settling was noticed, the seam was said to be close. The drill was then started again, and if it continued to race the number of hundredths of a foot were noted until the bit again encountered harder rock.

These indicated seams were later checked with the core to confirm the interpretation of the drill running, and in very few cases were they found to be in error.

The apparatus used to apply pressure to the borings as shown in Fig. 3 is similar in general construction to that used by Mr. Wm. E. Swift, Division Engineer, Northern Aqueduct Department, and consists essentially of the following parts: A Douglas hand pump, 50 ft. of 1-in. rubber discharge hose, a pressure gage, sufficient lengths of 1-in. and $\frac{3}{8}$-in. pipe to reach the desired point in the bore, two sets of gutta percha washers, and a perforated spacer of $\frac{3}{4}$-in. pipe to fit between the two sets of washers.

The $\frac{3}{8}$-in. pipe is loosely telescoped into the 1-in. pipe, both of which extend into the bore.

To the bottom of the $\frac{3}{8}$-in. pipe is fitted a plug and a half union. Above this half union is placed a set of 5 gutta percha washers, each $\frac{1}{2}$ in. thick, which fit snugly to the $\frac{3}{8}$-in. pipe and have an outside diameter of $\frac{1}{8}$ in. less than the diameter of the bore.

Between this and the upper set of washers is a spacer of $\frac{3}{4}$-in. perforated pipe. The upper face of the second set of washers bears directly against the bottom of the outer 1-in. pipe.

The $\frac{3}{8}$-in. pipe between the two sets of washers is perforated.

To expand the rubbers for a test in a boring, the inner $\frac{3}{8}$-in. pipe is pulled up a short distance through the 1-in. pipe by means of a simple screw thread device attached to the top of the $\frac{3}{8}$-in. pipe. As the outer pipe is held stationary the pull is transmitted from the bottom half union of the $\frac{3}{8}$-in. pipe to the lower rubbers, and through them to the upper rubbers by the sliding spacer of $\frac{3}{4}$-in. pipe. As the outside pipe is held stationary by a clamp at the top, the pull gives a squeezing action to the rubbers, thereby expanding them tightly against the wall of the bore.

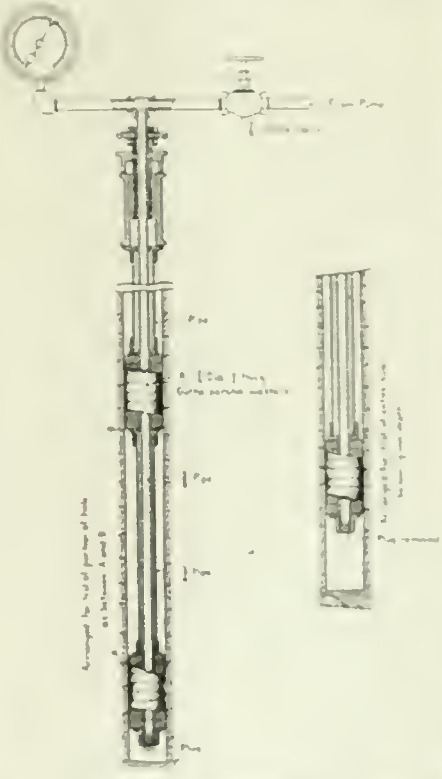


Fig. 3. Details of Apparatus for Testing Borings by Hydraulic Pressure.

To make a complete test, the rubbers were expanded in place and water pumped down through the inner pipe, escaping through the perforations in this and the $\frac{3}{4}$-in. spacer pipe to the rock wall [illegible] between the two sets of rubbers.

A standard of [illegible] gage pressure was assumed [illegible] in the [illegible] pressure. When this pressure was reached the time was noted and the loss in pounds, if any, indicated on the gage at the end of 60 seconds recorded.

If a leak was encountered, the pressure fell off very rapidly between each stroke of the pump, and the gage was said to "race."

Nine [illegible] were subjected to water pressure tests and the results recorded. These tests were conducted foot by foot progressively from the top to the bottom of the bore, except where sound rock was encountered for a considerable distance, when a 4-ft. spacer was used, testing four consecutive feet at a time.

If, at any test, decided loss of pressure occurred, i. e., 10 lb. or more in one minute, the weak spot was located to the tenth of a foot in the following manner:

The core was first examined. This would usually show the approximate location of the seam. The tester was then raised so that the bottom rubbers would come above the leak and a test made. If this indicated tight rock, succeeding tests were taken at intervals of 0.1 ft. until a decided loss in pressure was again noted. The bottom of the leak was also located by running up with successive tests from below.

This method was effective except where two or more seams might occur less than a foot apart. In such event the record shows a loss for the whole foot, or from the top of the first leak to the bottom of the last one.

A curve was worked out from the results of experiments to establish a relation between the indicated loss in pounds per minute and the parts of a gallon lost per minute. These results were obtained as follows:

A piece of pipe about 2 ft. long with a valve tapped into the middle of it was substituted for the rock wall of the bore, and the rubbers expanded in this pipe to a tight contact similar to that obtained in testing the rock. About thirty-five pressure tests were then made ranging from the valve closed, with an indicated loss of 2 lb., to the valve wide open with a full racing gage.

At each test the amount of escaped water was measured and the number of pounds pressure lost was recorded. By plotting these results the curve above mentioned was obtained.

From an inspection of the curve it was seen that a very slight leak would cause a heavy loss in pounds pressure. The maximum loss obtained in the tests equalled about [illegible] gallons per minute.

Progress on the Belle Fourche Project of the U. S. Reclamation Service is reported as follows in the June Reclamation Record: In Belle Fourche Dam two steam shovels and three graders have been operated during the month, about [illegible] cu. yds. of material having been placed in the embankment. About [illegible] sq. yds. of the upstream slope [illegible] was finished, and on this slope [illegible] cu. yds. of [illegible] gravel were laid in place and rolled, and approximately the same amount of screened gravel was placed. The laying of paving blocks was begun on the [illegible] and [illegible] have been placed. [illegible]

During [illegible] were [illegible] for the [illegible] Government at a [illegible] cost of $[illegible].

British Methods of Competitive Bidding on Building Work.

Sirs: As a London surveyor of some twelve years' experience—now working for an American firm of contractors—the writer would like to comment briefly on the article having the above title in your issue of June 9.

The system of bidding on quantities supplied is now practically universal in England. Building works of any magnitude executed on a percentage basis are exceedingly rare, as the advantages of quantities are so much greater. Your contributor is incorrect in stating that many bills of quantities include a clause putting liability for inaccurate quantities onto the builder. No surveyor of repute would do this, and few architects would entrust work to a man who could not be sure enough of his work to accept responsibility for it; nor would many builders care to bid on such quantities.

Although in most contracts the quantity surveyor is liable for errors in his bills of quantities, it is a very rare thing for any quantity surveyor to pay such out of his own pocket. Although serious mistakes are seldom made, yet no surveyor can be infallible, where a mistake is found it is usually treated as a variation, and adjusted at the settlement of accounts at the end of the job. Legally, however, the surveyor is liable, as it is not usual to make quantities a part of the contract.

The schedule of charges published have not been generally adopted by the quantity surveying profession. The rates are lower than usually obtain, and also it is not customary to include the cost of printing or lithography in the surveyor's percentage. In a small job of public work, where perhaps twenty bidders are to be supplied with quantities, the lithography would cost more than the fees. The advantages of bidding on quantities are many. In particular the closer bidding, and the provision of a basis for adjustment of variations commend them to the owner and the architect, and the absence of risk to the contractor, and the great saving of time in making the estimate makes it attractive to the builder.

The system is, however, far from perfect. The amount of minute detail usually included in a bill would astonish the American contractor. I have known as many as 40 items to be required in taking off a single window, and the bill of quantities for an office building costing £40,000 will often run into as many as 150 foolscap pages. In spite of this it is preferable to the present system of bidding in this country, where the estimator is given a week or less to fully understand, and take off from plans which the architect may have taken months to prepare, and where he has to assume the risk of errors in estimating quantities, as well as the risk of errors in pricing, which naturally should fall on him, and which involves the expense of spending days on taking off work which he never gets; work on which the English builder would spend as many hours.

It seems to the writer that a modification of the English system could be introduced with advantage into this country if a general wish were expressed on the part of contractors for the same. There are undoubtedly difficulties in the way of its adoption; the chief one being the absence of any rules of measurement, to which all builders conform, but this, undoubtedly, could be straightened out in time.

Yours truly,
LESLIE H. ALLEN.

8 Beacon St., Boston, Mass., June 15, 1909.

Personals.

Mr. Walter E. Winn has been appointed City Engineer of Danville, Ill.

H. Engelbright and H. Charonnat have opened an engineering office in Nevada City, Nev.

Patrick Dunphy, of the firm of Dunphy & Nelson, railroad contractors, died early this month at Mercy Hospital, Pueblo, Colo., after a long illness.

Mr. Wm. S. Hartman has been appointed City Engineer of Bozeman, Mont. Mr. Hartman at present is connected with the engineering staff of the Panama Canal.

Mr. Irwin S. Lloyd, C. E., lately with the Missouri Pacific R. R., has returned to Concord, N. H., and reopened the office of Lloyd & Mann, civil engineers, at No. 2½ No. Mann St.

Mr. Howard Carson, M. Am. Soc. C. E., has resigned his position as chief engineer of the Boston Transit Commission. Mr. Carson has designed and directed the construction of practically all of the elevated and subway lines in Boston.

Mr. W. S. Dawley has resigned his position as Chief Engineer of the Missouri & North Arkansas R. R., and has accepted a similar position for the construction of a railroad in the interior of China. The road is to be constructed for the Chinese Government.

Mr. John E. Shoemaker, until recently constructing engineer for the city distributing system at Camaguey, Cuba, has entered the employ of Field, Fellows & Hinderlinder, civil engineers, Denver, Colo. Mr. Shoemaker will be engaged upon preliminary surveys for an irrigation project near Pueblo, Colo.

Mr. Earle K. Knight, until recently constructing engineer in charge of the building of the main pipe line and concrete reservoir for the new $800,000 water works at Camaguey, Cuba, has become principal assistant engineer for the firm of Hazlehurst & Anderson, consulting engineers, 926 Candler Building, Atlanta, Ga.

Mr. Francis T. Bacon, formerly architect for the Illinois Central R. R., died in Chicago on June 18, aged 43 years. For two years Mr. Bacon had been in private practice. While with the railway company he designed, among other buildings for the company, the Van Buren St. Station and the 10-story annex to the 12th St. Station in Chicago, and the Union Station in Memphis, and the great warehouses at New Orleans.

The U. S. Civil Commission has announced the following examinations to be held next month in the principal cities of the country: Computer in the Supervising Architect's Office, Treasury Department; examination to be held July 8-9. Aid, Coast and Geodetic Survey (four vacancies in the position of deck officer at $76 per month); examination to be held July 8-9. Architectural Draftsman, $1,500 per annum in Quartermaster's Department at Large, Philippines Division; examination to be held July 14-15. Topographic Draftsman at $900 per annum in Coast and Geodetic Survey; examination to be held July 14-15. Engineer in wood preservation, Forest Service, at $1,000 per annum; examination to be held July 21-22. Application blanks can be obtained by addressing the U. S. Civil Service Commission at Washington, D. C.

The following changes have been made in the Engineering Department of the U. S. Reclamation Service: Appointments—Mr. E. H. Elder, junior engineer, Sunnyside unit, Yakima Project; Mr. H. W. Griswold, junior engineer, Yakima Project; Mr. A. E. Geiger, junior engineer, office of supervising engineer, Portland, Ore.; Mr. J. C. Heinz, junior engineer, Wapato unit, Yakima Project; Mr. E. S. Taylor, assistant examiner, Umatilla Project; Mr. R. S. Thayer, junior engineer; Orland, Project; Mr. R. C. E. Weber, junior engineer, office of supervising engineer, Portland, Ore. Reinstatement—Mr. F. C. Youngblutt, junior engineer, from Sun River Project. Transfers—Mr. E. H. Baldwin, engineer, from Pathfinder Dam to Yakima Project; Mr. J. S. Conway, engineer, from Orland Project to Yakima Project; Mr. B. H. Davis, engineer, from Sunnyside unit, Yakima Project, to Klamath Project; Mr. J. D. Fauntleroy, engineer, from Yuma Project to Yakima Project; Mr. R. D. Hubbard, assistant engineer, from Klamath Project to Malheur Project; Mr. J. L. Rhead, assistant engineer, from Orland Project to Malheur Project. Separations—Mr. O. W. Peterson, assistant engineer, resigned; Mr. W. D. S. McCormick, junior engineer, expiration of furlough; Mr. W. A. Keddie, engineer, expiration of furlough.

Catalogs Worth Having.

Engineers and contractors should have on file the latest catalogs of machines, tools and supplies that they use. In sending for catalogs reviewed or advertised in this paper, you will confer a favor on us if you will write direct to the advertisers and state that you saw the catalog mentioned in ENGINEERING-CONTRACTING. If you are in the market for tools, machinery or supplies, tell us and we will notify promptly the leading manufacturers.

No. 1286. **Industrial Locomotives.**—Ernest Wiener Co., 50 Church St., New York.

A 7-page pamphlet, well printed and illustrated, describing a gasoline motor to be used by the contractors and manufacturers on industrial railways in place of the ordinary dinkeys.

No. 1287. **Expansion Bolts.**—Diamond Expansion Bolt Co., 90 West St., New York.

A 24-page catalog describing and illustrating expansion bolts, anchor screws, shutter eyes, insulator brackets, and various appliances of this character for use in concrete, brick, stone and masonry.

No. 1288. **Street Railway and Telephone Material.**—Newhall Chain, Forge & Iron Co., 9 Murray St., New York.

This is a 24-page book devoted to cross-arm braces and fittings, guy clamps and thimbles, bolts and pole steps, turn buckles, digging tools and washers, all for use in connecting with the overhead work of street railways and telephone and telegraph lines.

No. 1289. **Forgings and Castings.**—Newhall Chain Forge & Iron Co., 9 Murray St., New York.

In this 32-page catalog chains for many purposes, connecting links, hooks, shackles, boat spikes, rafting dogs, davits, checks and cleats, posts and towing tits and scow castings made by this well known firm are illustrated and described.

No. 1290. **Cars, Hoisting Engines and Derrick Fittings.**—New Jersey Foundry & Machine Co., 15 Murray St., New York.

This is a 27-page catalog describing and illustrating small wooden dump cars, of the rotary, side dump and hopper bottom type; flat cars for various purposes; derrick fittings, scale boxes and dump buckets; hoisting engines, locomotive cranes, and equipment of industrial railways.

No. 1291. **Glimpses of the Panama Canal.**—Wood Drill Works, 30-36 Dale Ave., Paterson, N. J.

This is an attractive pamphlet telling in an interesting manner of the wonderful work being done at Panama, where Wood drills are being used.

No. 1292. **Hand Street Sweepers.** — The Barron & Cole Co., Barron Building, New York.

A 27-page catalog of the Peerless Pick Up Hand Street Sweepers, which is said to be an economical and sanitary machine, adapted to smooth pavements, warehouse platforms, bridges and similar structures.

No. 1293. **Sprinkling Wagons.**—E. D. Etnyre & Co., Oregon, Ill.

A 16-page catalog, well printed, describing and illustrating the various sprinkling wagons made by this company. A very good catalog.

No. 1294. **Metal Gaskets.**—U. S. Indestructible Gasket Co., 50 Church St., New York.

A bulletin telling of metal gaskets of all kinds and giving a price list.

No. 1295. **Pressed Steel Plank Holders.**—J. H. Sullivan, Grand Rapids, Mich.

This 54-page pamphlet describes the construction of and the methods of using the Sullivan plank holders for concrete forms. The pamphlet is a useful one and contractors for concrete work will find its presentation of the merits and uses of the device named of interest.

No. 1296. **Steam Shovels.**—The Thew Automatic Shovel Co., Lorain, O.

This 48-page catalog illustrates the full line of steam shovels made by the above firm and describes each in detail. This shovel has a full circle swing and is novel in having a special horizontal dipper crowding motion of great amplitude which permits the shovel to work efficiently in very shallow cuts. Contractors will be interested by this catalog.

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The Common Confusion of the Terms Depreciation and Repairs.

Any engineer who [illegible] engineering literature relating to cost can not fail to be impressed with the fact that few writers have had a clear conception of the meaning of the word depreciation. The moment a [illegible] is purchased it begins to depreciate, whether it is used or not. For the purposes of [illegible] will be developed with comparative [illegible] [illegible] as depreciation. [illegible] should [illegible] usually regarded [illegible].

A [illegible] said to "depreciate" [illegible] "depreciation" [illegible] renewals of parts [illegible] repairs. Such "depreciation" should always be charged to repairs, and should never be [illegible] under the head of depreciation.

It may seem that this is mere [illegible] with words, but in any discussion the first essential is to define the terms that are to be used, and then to adhere always to the definitions.

Due to the fact that confusion exists at present, it is a very common thing to run across an engineer's estimate of the cost of maintaining machinery which contains an item of 5 per cent for "depreciation." Further examination of the estimate discloses nothing for repairs, making it evident that the engineer intended to include repairs under his 5 per cent allowance for "depreciation." Such estimates are almost invariably ridiculously low, for while true depreciation may be—and usually is—no more than 5 per cent per annum, current repairs are usually 5 to 20 per cent in addition, for all the heavier classes of machinery. We recall seeing an estimate of this sort not long ago relative to operating and maintaining a dredge. The estimate was grossly in error, and from this erroneous estimate the inference was drawn that it would be cheaper for the government to own dredges than to contract for the work.

A locomotive has a true depreciation of less than 5 per cent per annum, but the cost of renewals (of parts) and repairs usually exceeds 15 per cent.

True annual depreciation is either the reciprocal of the life of the machine or it is the percentage of the first cost annually put into a sinking fund to redeem the machine at the end of its life. If a machine has a life of 20 years, it may be said to depreciate 5 per cent per annum, and this is, in our opinion, a correct method of arriving at its "present value," or depreciated value. On the other hand, if [illegible] per cent of its first cost is put annually into a sinking fund drawing compound interest at ordinary rates [illegible] at the end of 20 years the [illegible] the original investment. [illegible]

The cost of repairs is [illegible] as a percentage of the first cost, but [illegible] work. If a machine is idle most of the year [illegible] a little more than 100 days worked [illegible] error in [illegible] repairs upon a percentage basis [illegible] that the [illegible] a large part of the year. It is greatly to be desired that all records of annual repair costs be given both as a percentage of the first cost of the machine and as so many cents, or fractions of a cent, per unit of work done. Thus the annual cost of repairing a rock crusher should be given as a percentage of the first cost of the crusher as well as so many cents per cubic yard of crushed rock.

While true depreciation is a constant percentage per annum, the item of repairs is a variable percentage, gradually increasing as the machine grows older. Hence in recording the cost of repairs it is always desirable to give the age of the machine and the total number of units of work it has done during its life.

This has been truly called the machinery age, but it is a sad commentary upon engineers of all classes that reliable and complete information as to the cost of repairs on machinery is almost wholly wanting. Aside from data relating to the operation of railway cars and locomotives, there are no published statistics of much value covering the cost of repairs on any given class of machinery. We have searched the proceedings of the American Society of Mechanical Engineers—as well as of every other American and English engineering society—for records of the cost of repairs to machines, and while we have found a very [illegible] amount of valuable information, it is [illegible] when one considers the great importance of the subject and the vast field from which information could be drawn.

A Macadam Specification That Needs Changing.

In the desire to secure [illegible] specifies the methods to be used by the contractor. As a general rule this is [illegible] [illegible]

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factory methods of securing a uniform thickness of the broken stone; but, even if there were none better than the method of using wooden blocks, there is one objection to this method which should cause it to be abandoned. We refer to the fact that the presence of cubes of wood in the road prevents the use of scraping or leveling machines for spreading heaps of broken stone. Where cubes of wood or where stakes are placed in the middle of a road, it is impossible to spread the stone except by hand. Hand spreading costs from 6 to 12 cts. more per cubic yard of loose stone than machine spreading, as we have shown previously in these columns. While hand spreading is still the almost universal practice, it is partly so because of the existence of just such specifications as we are now criticising.

A few short-sighted engineers may take the stand that since the contractor pays for the spreading, no matter how it is done, no favors should be shown by abandoning the old time method. However, it takes no argument to prove that the public pays the cost in the end, for the contractor bases his bid upon the actual cost. If machinery enables him to reduce the cost of a structure, the public ultimately secures similar structures at a lower price.

In this connection it is pertinent to remark that the grade stakes used in grading the shallow trench in which the macadam is to be laid should be driven neither in the center of that trench, as is often done, nor exactly on the lines of the sides of the trench. It has been the writer's practice to offset the grade stakes, placing them exactly 1 ft. outside the lines of the trench. The tops of the stakes should be driven so as to be exactly on a level with the surface of the finished macadam at the center of the road. Driven in this manner, the grade stakes will not be disturbed by the graders, nor by the men and teams spreading the broken stone, nor by the roller.

A wooden straight edge can then be laid across the top of opposite grade stakes, and measurements can be made down to subgrade or to grade. The proper distances down from the straight edge to grade should be marked at intervals upon the straight edge. This method is far more satisfactory both to the contractor and to the engineer than any other method that involves placing either wooden blocks or stakes within the lines to be occupied by the macadam.

For the benefit of our new readers we may add that the blade of the machine used to spread the piles of broken stone should be so raised as to cut off only a small part of the pile of stone each trip, spreading it little by little. No machine should be expected to give the finishing touches to the surface of the broken stone. After doing all the heavy work of spreading with the machine, use potato hooks or rakes to do the final smoothing of the surface.

Concrete and Reinforced Concrete Section

Note:—This section is devoted to methods and cost of constructing concrete and reinforced concrete structures. It will cover the selection, testing and proportioning of concrete materials; laboratory tests of concrete; concrete mixing, transportation and placing; fabrication and placing of reinforcement, and form construction and erection. It will also contain articles on new and interesting developments in the design of reinforced concrete.

Methods of Constructing Concrete Silos, With Some Data on Design.

II.

Wall Construction.

Methods of wall construction vary with the type of silo being built:

(1) The walls of solid monolithic concrete silos are built by depositing the wet concrete in forms or molds. The forms are circular in shape and two are used, one inside the other with a space between equal to the thickness of the wall.

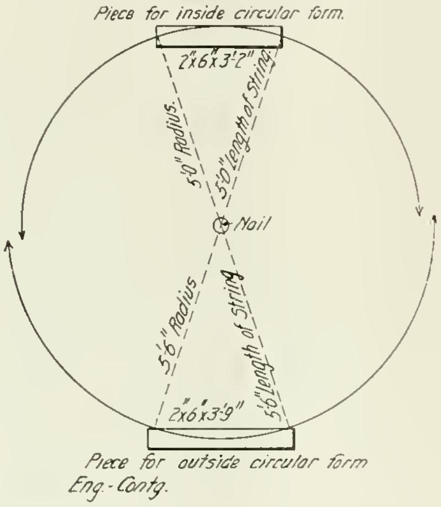

Fig. 3—Diagram for Laying Out Circular Rib Segments.

(2) The walls of hollow monolithic concrete silos are built by means of forms of the same character as those used for solid walls, with the addition of separate forms for molding the hollow spaces.

(3) The walls of concrete block silos are laid up, like stone masonry, of molded concrete blocks; no forms are employed.

The construction of monolithic walls, either solid or hollow, involve (a) form work; (b) reinforcing; (c) concreting, and (d) ladder, roof and door work. The construction of block walls involves: (a) block molding; (b) block laying and reinforcing, and (c) ladder, roof and door work.

Thickness of Walls.—Practice furnishes no standard for thickness of silo walls; examples show thicknesses varying from 6 ins. to 2 ft. Concrete silos were first built with very thick walls and without reinforcement; practice has changed to thin reinforced walls. In computing silo walls the usual assumption is that the reinforcement shall provide against all bursting strains. The thickness of concrete is, therefore, merely that thickness required for insulation, tightness and construction purposes. A 6-in. solid wall will satisfy the requirements for silos of ordinary dimensions and the wall should be of uniform thickness from bottom to top; making the wall thinner at the top does not save enough concrete to balance the extra cost of varying the size of the forms. Hollow monolithic walls require about a 3-in. air space and at least 3-in. shells so that the total thickness will not be less than 9 ins.; a 12-in. hollow wall is a good standard for ordinary size silos. Hollow block walls are usually made 10 to 12 ins. thick for the lower one-third and 8 to 10 ins. thick for the upper two-thirds of the height.

FORMS.

Forms for silo walls are usually built of wood, but several patented metal forms are on the market and any of the usual patterns of wood forms can, of course, be built of steel. The requisites of silo wall forms are: (1) strength, rigidity and invariability of shape; (2) lightness and convenience in erection and removal and simplicity in fabrication. Poor formwork is uneconomical, and gives often unsightly and sometimes unsafe structures. Formwork is, therefore, a part of the work to which careful attention should be given.

Forms for Solid Walls.—Movable forms are most convenient and economical; stationary forms are not considered here. The movable form consists of two concentric rings set one inside the other with a space between. The two rings are set first on the foundation and filled level full; after the concrete has hardened enough the rings are lifted until only the bottom edges still embrace the concrete and they are filled again. This process is repeated until the full height of the wall has been reached. The height of ring used varies from 16 ins. to 4 ft. The ring construction and the methods of moving and handling the rings vary. The following examples are from good practice.

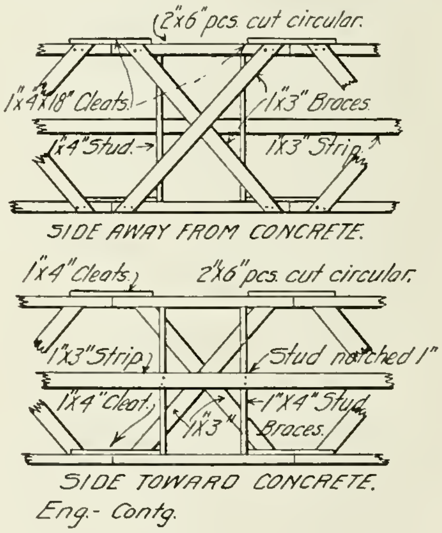

Fig. 4—Framing for Circular Forms.

Example I.—The forms described under this example were detailed by Gaylord and Wilson and they apply specifically to a 10x25-ft. silo, 6-in. walls, but the same construction is suitable for any other diameter of silo if the dimensions be changed as noted farther on.

The form illustrated consists of two circular rings set one inside the other with a 6-in. space between. Each ring consists of two circular ribs one at the top and one at the bottom connected by vertical and diagonal bracing. These ribs form the frame to which the sheeting is attached. In the form illustrated this sheeting is steel plates, but board sheeting may be employed if desired by making some slight modifications in the construction to be described. The rings are both 3 ft. high, so that 32 ins. in height of wall can be built at one time without shifting the forms. After this 32 ins. of wall has been completed the forms are loosened by means of adjusting bolts, raised by levers and tightened up again for constructing another 32 ins. height of wall. This operation is repeated until the full height of the wall is reached.

To lay out the wooden ribs proceed as follows: Plank 2x6 ins. in size is used for ribs. On any level platform like a barn floor, make a "center" by driving a wire nail. Loop one end of the cord or wire over this nail so that its other end may be swung around in a circle. This cord is used to mark the curves on the inside faces of the ribs. Each circular rib will consist of a number of sections or segments whose number and length will depend upon the diameter of the silo and the thickness of the wall. The numbers and the lengths of segments required for silos of different diameters, but with a uniform wall thickness, are given in Table IV, with radius of circle and other details.

From Table IV it is seen that for a 16-ft. silo 20 segments each 3 ft. 2 ins. long are required for the two ribs of the inside form. From the stock of 2x6-in. planks saw 20 3-ft. 2-in. lengths. The next step is to mark the curve to which the inside faces of these 2x6-in. pieces are to be sawed. Referring to Table IV it will be seen that the radius of this curve is 5 ft. for inside forms. With the "center" and cord or wire previously prepared, mark a circle on the floor whose radius is 5 ft., as shown by the upper half of Fig. 3. On this marked circle set the 3 ft. 2 in. piece as shown so that its outer edge at the center comes even with the mark. Then with the cord or wire mark the circle on top of the 3-ft. 2-in. piece and also mark the bevel of ends where the string when taut cuts across the corners. Saw the piece along these marks and one segment of inside rib is completed. The other 19 segments are made in the same way.

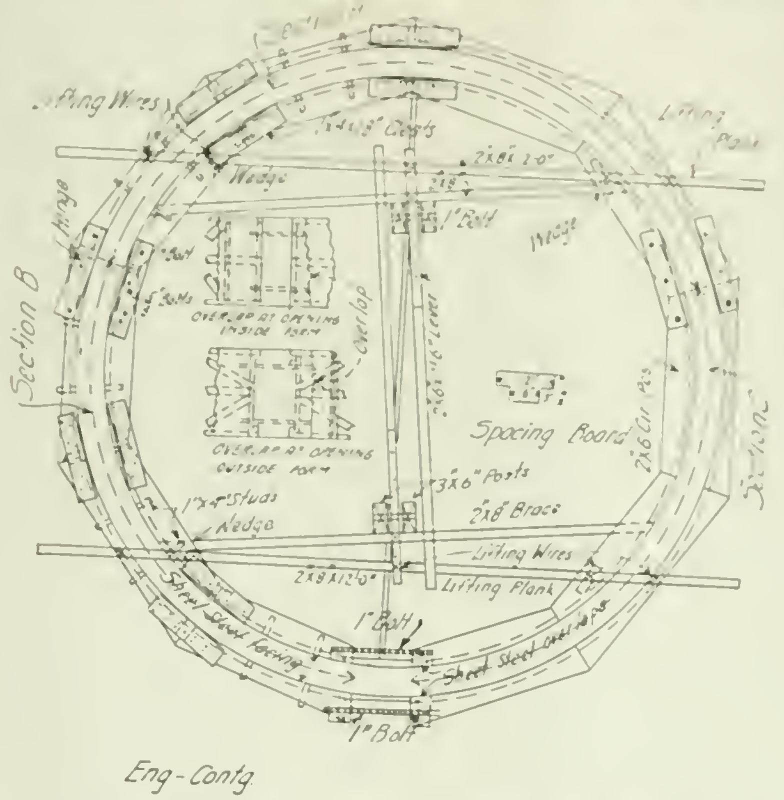

Fig. 5—Plan of Forms in Place and of Staging for Their Operation.

To make the segments for the outside form ribs the procedure is exactly the same, but the dimensions of the segments are different and the curve to which they are marked is larger, as indicated by the lower half of Fig. 3. The size of segments, radius of curve, etc., are got from Table IV, as before. As also Table IV gives these data for silos of any diameter up to 30 ft.

The segments being cut to size and shape, the next step is to connect them so as to complete ribs, two for the inside form and two for the outside form. These ribs are not made in one rigid piece each, but each is divided into three sections, A, B and C, to provide for adjustment and moving. To assemble a section of rib, section A for example of an inside rib, look in Table IV opposite the 16-ft. diameter in the first column and it will be found that 11 of the 3-ft. 2-in. segments are required. Place these segments end to end on the 5-ft. diameter circle marked on the floor, Fig. 3, and connect them together by nailing 1x6-in. cleats across the joints. Then assemble and cleat together a second section of segments exactly like the first. We now have two sections A of inside ribs, one for the top and one for the bottom. Leaving the last assembled section on the floor, erect on it vertical 1x4-in. studs and on top of these studs place the section of rib first assembled. The curved faces of the two rib sections should be plumb one above the other at all points, and the edges of the 1x4-in. studs should be plumb and flush with the curved faces of the rib sections. Use two studs for each 3-ft. 2-in. segment. Next connect the top rib section with the bottom rib section on the side away from their curved faces by a pair of diagonal braces to each 3-ft. 2-in. segment. Next notch the 1x4-in. studs on the edges flush with the curved faces of the rib sections and spring a 1x3-in. board into the notches and nail it to each stud. The face of this board should be just flush with the edges of the studs and, therefore, with the curved faces of the rib sections. This completes the construction of the framework for one section A of the inside form as shown by Fig. 4. The steel sheeting is fastened to the curved face of this framework. The construction of sections B and C is carried out exactly like the construction of section A.

The next step is to assemble the three sections of ring to make the complete inside form. Figures 5 and 6 show a plan and a transverse section of the completed forms in position. Referring to the inside form Fig. 5 it will be seen that section A is connected to sections B and C by hinges and that sections B and C are connected to each other by adjusting bolts. The hinges are constructed as shown by Fig. 7, but the 1-in. bolt is not placed

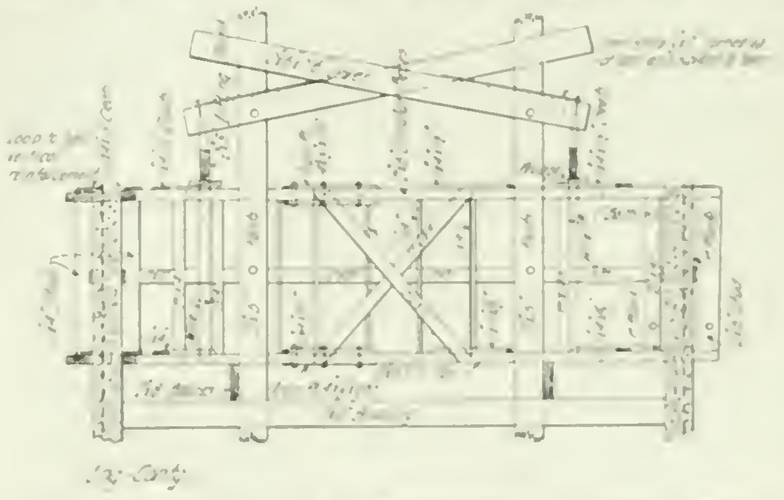

Fig. 6—Section of Forms Showing Staging and Operating Levers.

until the forms are erected. The 1-in. space left between the ends of the sections to allow play of the hinges results in sections *B* and *C* overlapping where they join. This overlap is removed by cutting the ends back and also framing them as shown by Fig. 8 to leave a 12-in. opening which is held together by two adjusting bolts. This opening is closed, when the forms are in place, by a shutter 1x3 ft. in size made of two 1x6-in.x3-ft. boards fastened together by cleats.

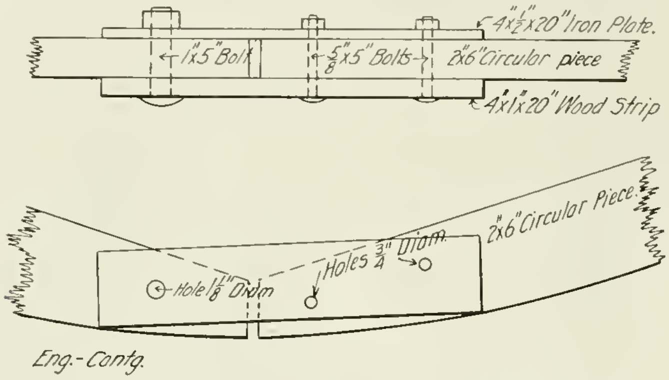

Fig. 7—Details of Hinge Connecting Sections.

As stated above, the sheeting of the forms illustrated is of steel plates. A 24-gage steel is used and is fastened to the form frames by nailing. The size of sheets to be used will be whatever size can be got that will fit best. Horizontal joints should be avoided if possible, but if unavoidable the joint should come over the 1x3-in. circular strip. Vertical joints should come over the edges of the 1x4-in. studs. At hinges the sheeting should be left lapping about 2 ins., enough to prevent an open space but not enough to hinder the free operation of the hinges. There should also be a 14-in. overlap at the adjustable joint.

As stated above, the sheeting may consist of vertical boards if desired. Sound and clear 1-in. tongued and grooved boards not over 6 ins. wide should be used. If boards are to be used their thickness must be provided for in cutting the rib segments. This is simply done by using a 4-ft. 11-in. cord or wire instead of one 5 ft. long for marking the 3-ft. 2-in. segments, and by using a 5-ft. 7-in. cord or wire instead of one 5 ft. 6 ins. long for marking the outside ring segments. The sheeting boards should be dressed on the face next to the concrete.

It will be seen from the proceeding description that the forms are divided into small enough separate sections to be handled conveniently. The methods of erecting and manoeuvering these forms will now be described.

Erecting and Moving Forms.—The method of erecting and moving the forms described in Example 1 is as follows: On the concrete footing prepared as described in a preceding section set up the four sections of the inside form, so that the open joints will come on the side at which the hoisting of the concrete will be done. Next place the hinge bolts in the ends of section *A* and the adjusting bolts in the open joints between sections *B* and *C*. Get the form on exact center and level it up carefully. Next set up and connect up the outside form. Center it with respect to the inside form by means of the spacing boards shown by Fig. 5, which should be spaced about 3 ft. apart around the circle, and by tightening the adjusting bolts. The forms are now ready to be filled with the first course of concrete.

To shift the forms upward for the second and succeeding courses of concrete a scaffolding and form lifting device are necessary. These are constructed as follows: The scaffolding consists of two pairs of 3x6-in. posts located and braced as shown by Figs. 5 and 6. In regard to location, do not place the two pairs of posts directly in line, but as shown by Fig. 5; this will give clearance to the lever arms. The distance apart of the two pairs of posts should be 5 ft. for a 10-ft. silo and 6 ins. further apart for every 1 ft. increase in diameter of silo. For the posts use 12 or 16-ft. lengths and splice them as shown by Fig. 9 to get the required height. When splicing see that both posts of a pair are not spliced at the same height, but splice one at a height of about 3 ft. above the splice in the other.

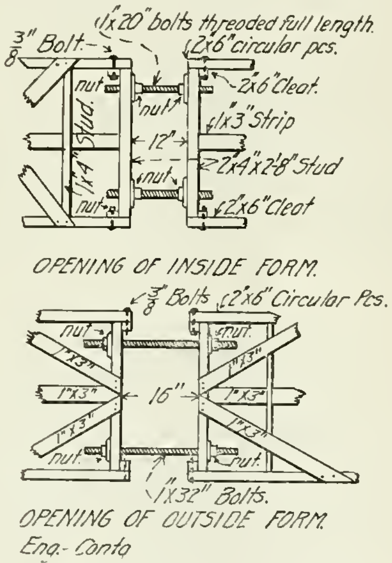

Fig. 8—Details of Adjustable Joint.

To erect the posts first lay two 2x12-in. planks across the silo floor for the posts to stand on and cleat the bottoms of the posts to these planks. Plumb the posts and brace them upright by inclined braces running from the posts to stakes set in the ground outside of the footing. This bracing will be removed after the first course of wall has been completed and the permanent bracing shown by Figs. 5 and 6 will be substituted but carelessness should not be permitted in doing the temporary work; it should be firm and strong. The permanent bracing consists of three sets of horizontal struts nailed to the posts and having their ends bearing against the inside of the silo walls, as shown by Figs. 5 and 6.

The lifting device consists of two levers operating two lifting planks. Place the lifting planks, 2x8 ins.x12 ft., across the forms as shown by Fig. 5 and connect them by wire to the forms so that when these wires are pulled up taut there is a 2-in. space between bottoms of lifting planks and top edges of forms. For the first lifting the 2x8-in. planks will be wired to the top ribs of the forms only as the bottom ribs rest on the concrete, but before making the second lift wire together the top and bottom ribs as shown by Fig. 6 so that the top rib will not have to take all the strain.

After the lifting planks are placed measure on the posts 4 ft. above the top edge and bore 1⅛-in. holes through the posts to receive the lever bolts. As the work progresses upward successive lever bolt holes are necessary. These should be spaced apart just the height of the lift; thus if the 36-in. forms are left lapping the wall 4 ins. each lift will be 32 ins. and the bolt holes will be 32 ins. apart. The levers are now put in place between the posts, using 1-in. lever bolts 15 ins. long.

As the levers will only raise the forms 1 ft. at a time, three holds will have to be provided in order to raise the forms 3 ft. This is done by making three loops of wire, each 1 ft. shorter than the other, by means of which the ends of the levers are attached to the lifting plank (see Fig. 10). The longest of the loops is just long enough to attach the lifting board to the lever, when the short end of the lever is in the lowest possible position, as shown in Fig. 6.

Three more loops of wire are attached to the lifting planks, just long enough to slip over the bolt in the uprights, and in this way hold the forms, until the end of the lever can be attached to the second loop.

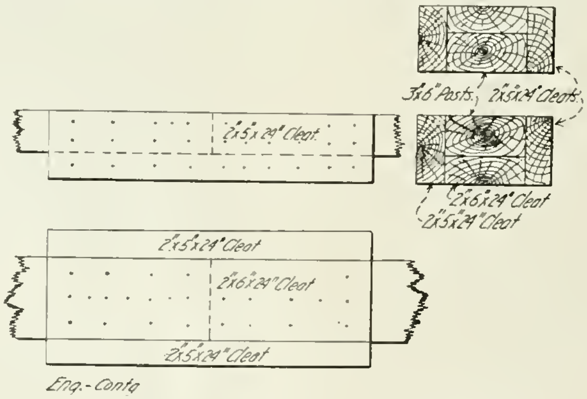

Fig. 9—Details of Splice for Staging Posts.

The shortest wire should hold the form about 1 in. higher than is finally desired. With the form held on the third or shortest hoop, place two 2x8-in. braces under the form. These two pieces of 2x8-in. plank should be measured and cut to fit against the silo wall when they are nailed across the 1x6-in. posts. Level these braces carefully and nail them to the posts at a point just 4 in. below the top of the fresh concrete in the walls.

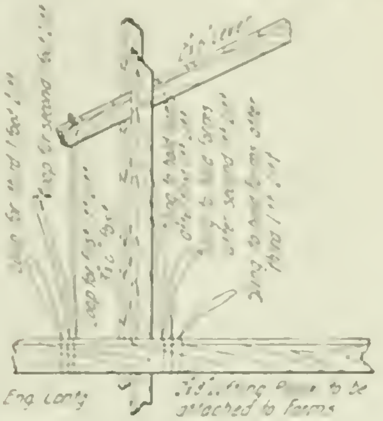

Fig. 10—Details of Lifting Lever.

Lay a straight edge across the top of the forms before lifting, and make a mark on the posts 4 ins. below this edge. After the forms are raised, nail the two 2x8-in. braces to the posts, with the top edges at the mark. Brace the ends of the 2x8-in. planks with 1x6-in. boards, and further brace the posts whenever necessary as the work progresses, as shown in Fig. 6. With the weight of the forms on the levers, take off the loops over the bolt and lower the forms till the inside form rests on the 2x8-in. brace. Holding the levers in this position, expand the inside form into position with the adjusting bolts. Now lower the outside form in the same way, using the 6-in. spacing board to keep the two forms the correct distance apart at the top. Drive small wedges between the 2x8-in.x12-ft. lifting pieces and the inside form so that the play in the wires between the 2x8-in. planks and the inside form will be taken up after the levers are released. These wedges will hold the 2x8-in. lifting pieces in place and they, in can now be released, and the form in turn, hold the outside form. The levers again ready for concrete.

Table V shows for various diameters of silos the sizes of wires, levers, braces and lifting planks required.

Messrs. Gaylord and Wilson cite the following cautions in handling these forms as described: (1) Do not raise the forms clear of the finished wall, as trouble will be had in getting them back again. (2) Be careful to raise the forms slowly and to work both levers at the same time in raising, so that the forms will not bind.

Example 11.—The form illustrated by Fig. 11 is given by M. L. King as embodying a combination of the best features of all the wood forms which have come under his observation. This is a sectional form. Two rings are used one after the other in rotation, the bottom ring being removed and placed on top as fast as the concrete hardens. Structurally this form consists of loose staves held in place by wooden hoops; the essential details are shown by the several drawings. It is suggested that greater convenience might be obtained in handling this form by making the inner hoops with a joint like the outside hoops.

The method of handling these forms is as follows: Set the first hoops on the footing and center and level them. Then place the staves entirely around the form. Next place the top hoops to enclose the staves and tighten them. After the first ring is completed set the second row of staves and place and adjust the third hoop. By the time the second course of concrete has been placed the first course will have hardened and the bottom hoop and bottom row of staves can be removed and placed on top.

TABLE IV—SHOWING DIMENSIONS OF SEGMENTS REQUIRED FOR [illegible]

Diameter of Silo in feet	Inside Form: Radius of [illegible]	Length of [illegible]	Number of [illegible]	[illegible]	Outside Form: Length of [illegible]	Number [illegible]	Number of [illegible]	[illegible]
10	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4
11	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4
12	[illegible]	[illegible]	1	[illegible]	[illegible]	[illegible]	4	[illegible]
13	[illegible]	[illegible]	1	[illegible]	4	[illegible]	4	[illegible]
14	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4	[illegible]
15	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4	[illegible]
16	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4	[illegible]
17	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4	[illegible]
18	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4	[illegible]
19	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4	[illegible]
20	10'0"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4	[illegible]

TABLE V—GIVING SIZES OF WIRE, LEVER AND BRACES FOR SCAFFOLDING AND FORM RAISING DEVICE.

Diameter of Silo in feet	Gauge of wire for single strands on each side. Gauge No.	Size of [illegible]	Size [illegible]	Size of [illegible]
10	[illegible]	[illegible]	[illegible]	[illegible]
11	8	[illegible]	[illegible]	[illegible]
12	8	[illegible]	[illegible]	[illegible]
13	8	[illegible]	[illegible]	[illegible]
14	8	[illegible]	[illegible]	[illegible]
15	[illegible]	[illegible]	[illegible]	[illegible]
16	8	[illegible]	[illegible]	[illegible]
17	8	[illegible]	[illegible]	[illegible]
18	[illegible]	[illegible]	[illegible]	[illegible]
19	7	[illegible]	[illegible]	[illegible]
20	7	[illegible]	[illegible]	[illegible]

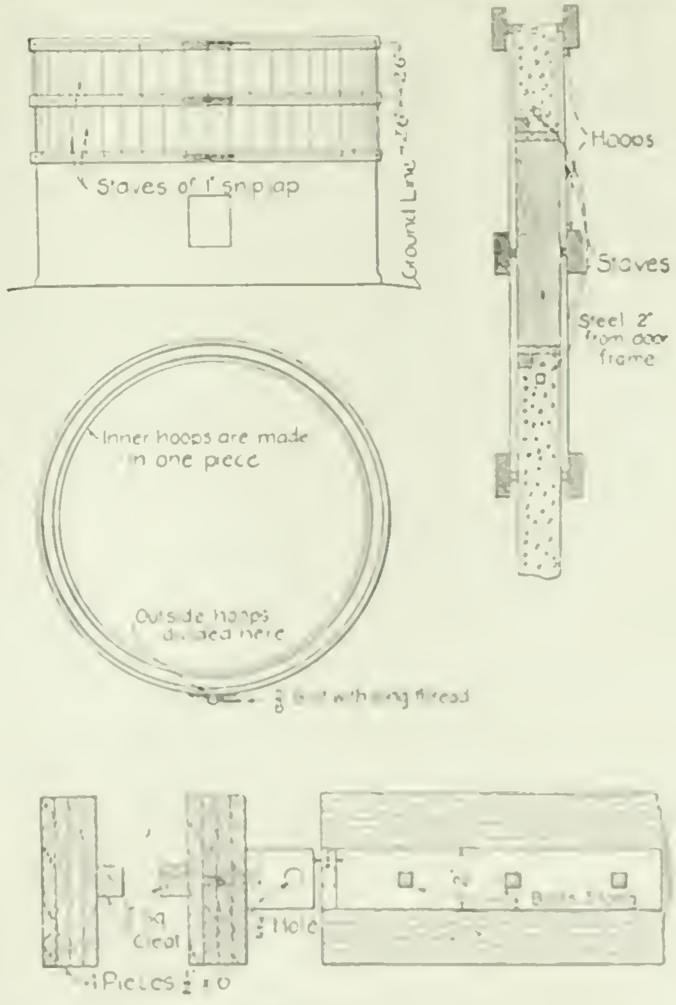

Fig. 11—Details of Sectional Forms for Silo Construction.

Methods of Molding and Driving Reinforced Concrete Piles and Sheet Piles for a Steamship Terminal and a Navy Yard Pier.*

The work was at the steamship terminals constructed for the Atlanta, Birmingham & Atlantic R. R., at Brunswick, Ga., and at the pier built for the U. S. Government at Charleston, S. C.

Steamship Terminals.—The terminals consisted of two piers, one 500 ft. long and 140 ft. wide, the other 900 ft. long and 140 ft. wide, with a coal trestle and a coal pier about 300 ft. in length and a basin 1,700 ft. long and 250 ft. wide. At the head of each pier were two warehouses 400 ft. in length and 80 ft. in width; there was also a power house 125 by 40 ft. Underneath the piers the concrete piles were used for the bearing piles entirely. They were driven on 12-ft. centers both crosswise and lengthwise of piers. The piles used under the terminals ranged from 30 to 51 ft. in length and weighed from 3 to 5 tons each. The reinforcement consisted of four 1¼-in. bars wound with spiral ¼-in. bars. At the head of the pile Clinton electric welded reinforcement came down about 4 ft. It was placed there to help stand the shock from hammering. A 1½-in. water jet was used. The piles were 16 in. sq. to within 10 ft. of the bottom and 8 in. sq. at the bottom. They had a 4-in. shoulder 16 in. from the head cast on two opposite sides that left a tenon at the head of the pile 8x16 in. The forms were made in one piece the entire length of the pile, the corners being beveled 1 in. The concrete was mixed in the proportions of 1 part cement, 2 parts sand and 3 parts broken stone and mixed very wet. The amount of water in concrete was determined entirely by the distance the concrete was carred in wheelbarrows, the mortar being kept just moist enough so that the stone would not settle to the bottom of the wheelbarrow. At first stone from 1-in. down was used. The concrete was made in a mixer and wheeled in barrows to the forms. Great care was used in tamping, as many as seven men being used to each pile, and the casting of each pile was made one continuous operation. After the piles were made the forms were removed in 24 hours. They were then kept moist for 7 days, at the end of which time they were picked up by means of a traveler and chain bridle and moved to the storage place, where they were kept for two weeks longer. At the end of that time they were taken to the floating pile drivers and driven.

A cast steel cap, sliding in the leads of the pile driver with a 4,500-lb. hammer was used in the driving of the piles. In the bottom of the cap was placed some rope and rubber and in the upper part a wooden block which the hammer struck. The cap was made to fit over the top of the tenon in the pile. It kept the pile from turning, so that in driving it could not get out of position, a very important thing, for it was necessary in this work to get the piles in exact position and keep them there. The first week we attempted to drive them by means of the water jet and hammer, but succeeded in getting down only 4, 5 and 6 piles a day. In fact, I don't know that we got down as many as 6. The driving was particularly deep. The piles were 51 ft. long and fully 40 ft. of them were driven in the ground. We were rather discouraged that it took so long to drive the piles and decided to try some other method, finally decided on the scheme of raising and dropping them. A wire bridle was fastened around the top of the pile, by which to lift it, the hammer and cap being allowed to remain on the top of the pile as an additional weight. The piles were raised from 18 ins. to 2 ft. and dropped. By this method we increased the driving until some days I have seen as many as 27 to 30 piles driven in 14 hours. The piles averaged from 30 to 51 ft. in length. On account of the water jet boring a hole ahead of the pile, it was found necessary in driving to shut off the jet and drive the last few inches by means of the hammer, the distance to be determined by experience according to the character of the bottom we were driving in. If we had good clear sand, we used to shut off the jet and drive the last 8 or 10 ins. with the hammer without any jet, the hammer dropping from 6 to 8 ft. The man running the level could determine very easily after he had become accustomed to it when to begin driving with the hammer.

The character of the bottom in the Brunswick work varied considerably. We had good clear sand and hard clay, some of the hardest I have ever seen. Also we had to drive through a stratum of soft rock composed of shell, sand and lime which was harder than any coral, and have driven many reinforced concrete piles through 2 ft. of it. Afterward we pulled some piles up that had been driven through this material and found the edges of bottom pile just slightly rounded off. There were about 6,000 piles driven and about 50 per cent of them through the above material.

At the head of the piers we drove a bulkhead of 6x14 in. reinforced concrete sheet piling. The piles had four reinforcing bars and one side of the bottom was beveled off the same as with wooden sheet piling to keep them together. We used no water jet on the inside of these piles, but on the outside, and in that way saved considerable pipe.

There is one thing that I have overlooked in speaking of the jet for concrete piles. The 1½-in. pipe was carried only one-third the length of the pile, coming out of the pile at the ground level in the shape of a reversed curve. We then used a separate piece of pipe on the pile driver long enough to extend down and to fit into the other pipe where it came out of the pile. That upper piece was taken out and used over again, the object being to save pipe, and we were able by this means to save from 25 to 30 ft. on each pile. We also found it feasible to use a jet the same size the entire length of the pile. A 1½-in. jet was used on the first pile we drove at Brunswick, and I tried putting a small end on it, but in every case we were able to drive the pile into position with a straight jet and do it quicker than we could with the jet reduced at the bottom. Out of all the 6,000 piles we drove I don't think I can remember more than one or two instances where the pipe clogged from driving. The jet seemed to be successful in keeping it open.

The sheet piling was of the same mixture of concrete as used in bearing piles, the proportions being 1-2-3 with stone of 1-in. in size. I do not deem it advisable from the experience I had, to use 6-in. sheet piling, and would not advise any less than 8 ins. in thickness. The shoulder and groove are so light on the 6-in. piling that it is difficult to keep the shoulders from breaking, while with 8-in. the joints were perfect.

Under the power house we drove some concrete piles; in fact, the entire building is supported on them, 14 in. sq. and 25 ft. long, with the same reinforcement as we used for the piers. But this method was abandoned afterward on the other work, for the reason that it was found we could drive pine piles, cut them off at the water level and put concrete piles on top of them cheaper than we could drive concrete piles.

The basin previously mentioned is 1,700 ft. long by 250 ft. wide. The construction in that is perhaps unique and more interesting than the concrete bearing piles.

We built a bulkhead with concrete sheet piles, 18 in. sq. and 45 ft. long and weighing 7 tons apiece. Pine piles were driven and a platform built on them on which the concrete piles were made. At the end the piles were beveled off to 12x18 ins. The reinforcement of these piles consisted of four ¾-in. corrugated bars running the entire length of the pile. For the lower two-thirds of the pile, that part from low-water mark down to the end, two 1¼-in. corrugated bars were put in to form a truss to take the strain where the maximum load came on the pile. We used a 2-in. water jet instead of a 1½-in. and found it much preferable. These piles had a tongue and groove on them. The proportions of concrete were 1-2-3, the same as in the other work.

The piles were made on the platform, 20 of them being cast in a day. They were allowed to set and kept moist seven days, at the end of which time they were picked up by means of a lighter, carried away to the storage pile and allowed to remain three weeks longer before being driven. The joints between the piles fitted very close, in fact much better than wooden sheeting. The bottom through which the piles were driven varied, I think, more than in the case of the other piles. Sometimes it was sand, then again very hard blue clay. In the case of these piles we drove them the entire way by churning, not using any hammer at all.

The number of piles driven on the Brunswick work was 5,426. The approximate cost of the terminals was $1,500,000. The two piers built cost about $1.40 per sq. ft., that is, figured on the surface of the dock. The cost of the 18-in. bulkhead was $75 per running foot complete, exclusive of the dredging. The work started July 5, 1906, and was completed May 1, 1907, or in eleven months.

Charleston Pier.—This pier was designed for the Charleston navy yard at Charleston, S. C., and is 60 ft. wide and 520 ft. long. It is built upon cast reinforced concrete piles of the same general design as those used in the Brunswick work. They are 55 ft. long and 18 ins. square to within 8 ft. of the bottom and then taper off to 12 in. square. The reinforcement of these piles consists of four 1¼-in. twisted bars and two ⅞-in. bars. The government asked the contractors to submit their own design for concrete piling, the cross-sections of which should be equal to 18 in. sq. and 7 sq. in. of reinforcement, and we could get the best arrangement of the reinforcement by the use of the rods I have mentioned. The ¼-in. bars are placed in the corners of the pile 2½ in. in from the outside. The two ⅞-in. bars were put in the pile 2½ in. in from the surface on opposite sides and on a line across the pier.

These piles were made on the same general scheme as the sheet piling at Brunswick. They were built on a platform, wooden forms were used, a 2-in. water jet 22 ft long was put into the pile and for the rest of the distance was outside. The piles were kept moist seven days and then picked up by means of a lighter and carried away to the storage pile. The scheme used for lifting these piles, which weighed 10 tons each, was to use a bridle consisting of two chains kept apart by a piece of yellow pine 18 ft long. Hanging down from each end of this piece of timber were two big timber hooks. These were used to lift the concrete piles. We had no trouble in lifting them. In fact, of all the piles driven at Brunswick or at Charleston, I never saw one broken from lifting it. We carried them from the storage pile to the site where the work was being done on lighters.

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*Condensed from a paper by M. M. Cannon read before the Boston Society of Civil Engineers on Sept. 16, 1908.

The bottom through which we drove the piles at Charleston consisted of marl, which is a yellow clay that is extremely hard and has, I think, about 15 per cent of sand and is very sticky. When it comes out in the open air inside of a few hours it is so hard that you have to use a hammer to break it. It is almost stone. For the first 50 ft of the pier the piles were driven through 38 ft of this marl, no sand whatever, but the very hardest kind of marl. The driving was done entirely by the churning process until we got within 2 or 3 ins. of the bottom, when they were driven to grade with a 1500-lb. hammer.

The work was started May 18 and was completed in three and a half months. The cost was $2.60 per sq. ft., almost double the cost of the Brunswick work, due principally to the fact that the piles were 10 ft on centers where we had 12 ft on centers at Brunswick, and to the heavier construction. For bracing the piers at low-water mark we put a pipe through the pile when casting it, which gave a hole 6 in. above low water through which a 1-in. bolt fastening two 6 by 12 in. low-water girders was placed. Also cross bracing was fastened to the superstructure and to these low-water girders.

The test load required in the case of the Charleston pier was 100 lb. to the sq. ft. or 20 tons to the pile and the government had the privilege, of course, of choosing any piles they wished us to test; instead of testing the piles at 20 tons to the pile, we loaded them to 30 and kept the load on for 48 hours. The piles stood up so well to this test that the government engineers were able to find no settlement whatever.

Bids for constructing additional sections of New York State barge canal were opened by F. C. Stevens, state superintendent of public works, at Albany, N. Y., June 23. On contract No. 30 for constructing 11 miles of the barge canal, Little Falls to Startling Creek, three bids were received, the Acme Engineering & Construction Co., of New York and Schenectady, being lowest at $2,591,666. The engineer's estimate on this contract was $2,650,500. On contract No. 36 for machinery for dams there was but one formal bid, Charles Longnecker & Co., of New York, at $10,910, as against the engineer's estimate of $14,000. On contract No. 42 for [illegible] miles of canal from the Herkimer-Oneida county line through Utica to Oriskany [illegible] bids were received. Stanley Merrill Co., Inc., of New York, was low, bidding $1,163,025, against the engineer's estimate of $1,1[illegible]814.

Work has been started on a valuation of the railroads of Oklahoma under the direction of the state corporation commission. The board having the work in charge will make personal trips covering the 5,605 miles of road within the state. And it is expected that the work will require many months.

Earth and Rock Section

Note: This Section is devoted to methods and costs of excavating earth and rock and building embankments. It will cover the grading of roads and railroads, diking and canal work, dredging, building reservoirs and earth dams, sewer and water pipe trenching, quarrying, etc.

Comments on Excavating Trenches with Machines.

(Continued from June 2[illegible] issue.)

When scrapers are used to excavate trenches, the shoring and bracing must be done subsequent to the work done by the scrapers as the braces interfere with their movement. However, when an orange peel bucket is used, the excavation by means of the bucket can be continued even after the shoring and bracing are placed.

The orange peel bucket is either worked by a locomotive crane or by a derrick car that is moved along the ground on skids or wheels. The crane or derrick is run on one side of the trench. The usual custom is to first excavate the trench to as great a depth as possible without danger of caving in the sides, and then place the shoring. Then, generally the rest of the excavation is done by hand, but if the bucket is being used with a locomotive crane, or by a derrick that is mounted on a car with wheels that can move under power, at a fair rate of speed, it would be possible to continue the excavation with the orange peel bucket. Likewise a cableway could be used with an orange peel bucket and the excavated earth used for backfilling, or be loaded into wagons or cars.

The orange peel bucket will excavate soft material very rapidly as the bucket fills well and quickly in it, but a bucket will also dig heavy clay, if it is well designed and has sufficient weight to it. After shoring is placed in a trench, the bucket cannot excavate under the braces, but only a few cents per cubic yard is added to the cost to have men cut out the material under the braces and cast it to where the bucket can pick it up. Engineers and contractors have not yet realized the great range of work that self loading buckets will do. It is very true that the uses of such buckets have increased wonderfully during the past decade, but there is still a great field of work to which they can be applied.

Steam shovels have been used for many years for trench excavation and each year shows more efficient work done by them. When shovels were built of the old crane type they did not have as great an angle of swing as the present trench digging shovels have, with the result that the dirt was piled up so close to the trench as to interfere with not only the work of excavation but also the other work that had to be done in the trench. The modern boom shovel was an improvement over the crane type, but the great improvement made in steam shovels for trench work was when the full circle swing shovel was introduced. The Thew Automatic Shovel Co., of Lorain, Ohio, was the first company to manufacture a shovel revolving in a circle of 360 degrees. Today several manufacturers make such shovels. With this type of shovel the excavated material can be kept well away from the trench and a large amount of material piled up on the bank. As the pile becomes high, the dipper of the shovel is used as a rake, pushing off the top of the pile of earth, and away from the trench.

For trench excavation the regular length dipper arm is taken off the shovel and a much longer dipper arm substituted. Trenches are dug with these long dipper arms from 14 to 18 ft deep, while in a few cases they have been taken to a depth of from 20 to 22 ft. Shovels mounted for trench work vary in weight from 35 to 45 tons. Heavier shovels than these are apt to cave in the banks of the trench and are very difficult to move. [illegible] shovel is often too heavy for this class of excavation. Such [illegible] shovels are usually mounted on traction wheels, although they can be mounted on railroad trucks. However, for trench work the shovels are generally taken off their trucks and mounted on sills or timbers that are trussed to give them additional strength. Track rails are not used along the trench at grade. Timbers, 12 by 12 ins., are generally used for this purpose. Some contractors have made a practice to build a platform across the trench and to place the shovel, mounted on its traction wheels, on this platform. It is evident that this is a wrong practice, as it makes the shovel a foot or two higher above the trench than it should be. The mounting of a shovel for trench work is of great importance, especially where a deep trench is to be excavated.

In Fig. 1, the usual method of mounting a shovel for narrow trench work is shown. Also the rollers on which it is moved. Heavy planks should always be laid down for the rollers to rest on, and it is generally well to have the rollers long enough to admit of two holes being bored through the ends so that bars can be used to straighten up the rollers when necessary, and also to move the machine by means of bars. However, the machine is not moved in that manner except when steam is not up. In Fig. 1 a small drum is shown beneath the machine. From this drum a hauling line (not illustrated) is run to a dead man placed several hundred feet ahead of the machine, and the shovel is moved by its own steam by winding up this line on the drum.

In Fig. 2 is shown sills properly trussed to carry the steam shovel over a wide trench. This photograph also shows the long dipper arm used for trench work. The shovel is mounted very low for deep digging. It is possible to carry the track rails below the natural surface of the ground in trench digging, so they will not interfere with the work if they are properly placed on the timbers. When the shovel is to be moved over the ground from one trench to another, the whole frame can be jacked up and trucks placed under the frame, [illegible] so that the [illegible] will not interfere with the ground as the shovel is moved. There is no reason, however, why heavy steel I-beams should not be used in place of the timbers, thus doing away with the truss rods, and channel beams could be used on each side in place of the longitudinal timbers, thus allowing the shovel to be mounted lower.

When shovels of the revolving type are used, and in the writer's opinion this type is the best for trench excavation, instead of mounting the shovels on a skeleton frame, a platform must be built to hold the turntable, thus adding to the height, however, with steel beams, this height could be reduced. A good motto to follow is to keep the shovel low. No matter how the machine is mounted, arrangements should be made to hold the shovel in its position while digging, for in hard excavation, unless this is done the shovel will back away from the breast and much time is lost.

Figure 2 shows how shoring is placed in a trench under a shovel. For this purpose the sheet piles should be cut to about the proper length, as they cannot be driven, but must be placed, and which the waling and trench braces are put in. In order to have the shoring conveniently at hand they are carried along on the framework that holds up the shovel. This saves much labor in carrying lumber over the piles of dirt, as it can be placed on the platform before dirt is thrown on the sides of the trench and then used as needed. If the banks will stand up until the shovel can be moved ahead it is always better to do the shoring afterwards, especially if the trench is to be taken deeper.

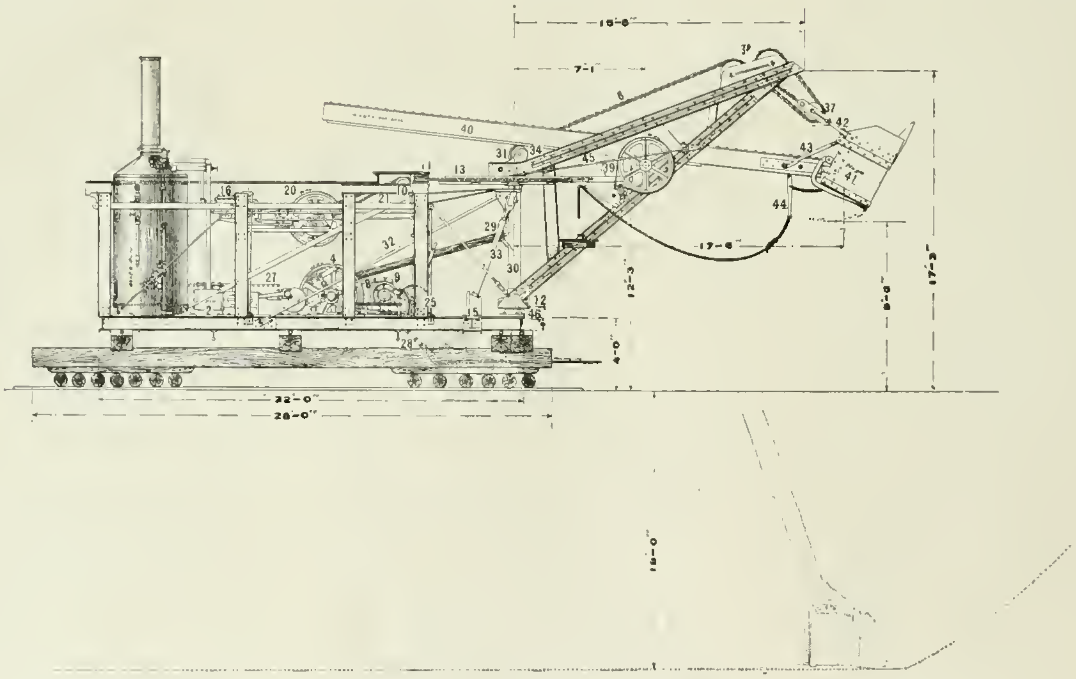

Fig. 1—Sketch Showing Usual Method of Mounting a Steam Shovel for Trench Work.

In the same illustration is also shown a drum in the car and the side lines, running to the dead man ahead, for moving the shovel. The shovels shown in these three illustrations are all Vulcan steam shovels, made by the Vulcan Steam Shovel Co., of Toledo, Ohio, who besides making shovels for various purposes, make a specialty of shovels for trench work and they now manufacture a shovel of the revolving type that is used for trench excavation.

Although as previously shown it is cheaper to place shoring in a trench after the shovel has been moved ahead, rather than do this work under the shovel, yet one should never take chances on banks caving in under the shovel. In very treacherous ground the shoring should always be kept right up to the point of digging, but it is also possible to brace the sides temporarily, where the danger is not very great. This temporary bracing and permanent shoring can be done cheaper than to do all the work under the machine and just ahead of it, as the movement of the dipper interferes with the work of the men.

One objection that is sometimes found to digging trenches with steam shovels is that the excavation is left in a very ragged condition. This is so, but the writer believes that more of the fault has been with the operators than with the machines, while sometimes the blame lies with the contractor who pushes his men to obtain a large yardage rather than have the work well done. There are two ways to overcome this objection. First, the trench can be dug a little wider than necessary and the shoring can be placed in the proper position and material filled in behind it. Some contractors claim that the faster work of the shovel compensates for the cost of the extra work. The second method is to clean up the trench with the shovel and the aid of the pit men, which really only means a few minutes of time, and a very low cost per cu. yd. of excavation if the trench is a wide one. In narrow trenches, the cost per cu. yd. of trimming up the trench is naturally much higher than in wide trenches.

For these and other reasons it has not been considered advisable to use steam shovels in narrow trenches. Even with a small dipper the trench should be at least 4 ft. wide, and the writer's experience is that in a trench of 6 ft. width the shovel is seldom economical. But in 8, 10 and 12 ft. and in wider trenches the steam shovel does excellent work. A steam shovel operating on the ground in ordinary excavation can do more work than in a trench as the dipper can be lowered to the work as the boom or shovel is swung around, while at work in a trench the dipper can only be lowered part of the distance, the operation being to swing into position first and then lower the dipper to the work. This takes much less time in a wide trench than in a narrow one; another factor entering into the speed and cost of the work being the depth of the trench. A narrow, deep trench, say from 4 to 6 ft. wide and 16 to 18 ft. in depth, will be rather slow digging for a shovel as compared to a wide trench even of the same depth. Naturally, too, on the narrow trench more time is lost in moving the shovel, as many more moves must be made.

Some of the manufacturers of locomotive cranes are now adapting their machines to be used as a steam shovel, by placing a dipper and dipper arm on the boom of the crane. Some very good work in excavation has already been done by these machines, and with a long dipper arm trench excavation can be done with them. One advantage they possess is, that as the boom can be readily lowered and raised, a deeper trench can be dug with such a machine than with a steam shovel, with the same length of dipper arm, but the rate of excavating, caused by raising and lowering the boom, would be slightly slower.

The writer has never seen a locomotive crane rigged as a steam shovel, with crowding engines on the boom, with the result that in hard digging it would be difficult to hold the dipper to its work. Likewise the boom not being held rigid as it is on a shovel, there would also be some give to it, in hard excavation. Nevertheless, if trenches of a depth greater than 20 or 22 ft. can be excavated by a crane a very decided advantage is gained, as the only way of excavating such a trench, besides doing it by hand, known to the writer, is by means of orange peel buckets or power scrapers and these cannot be used under all conditions.

The Stephens Excavating Machine is really a device that can be attached to a locomotive crane and used in excavating trenches. It is the invention of Mr. J. W. T. Stephens of New Orleans and has been used for work at Algiers, La., and other places in that locality with success.

The machine consists of a combined shovel cutter and an endless bucket elevator. The buckets, passing through the shovel boot, carry the excavated material to the head of the elevator boom, and discharge it onto a transverse conveyor belt, which can deliver into wagons, carts or cars, for removal, or in heaps, alongside of trench. If desired, a belt conveyor can be attached to carry the material back for refilling, in one operation, the belt being supported upon a light frame upon wheels, thus following the digger.

The machine travels ahead of the excavation and the shovel bucket or cut is pulled towards the machine, cutting the earth as it travels and delivering it to the boot from which it is carried to the conveyor by the elevator buckets. There is an attachment that cuts through roots and stumps. Trenches of various widths and depths can be dug with this machine and shoring can be placed right up to the deepest part of the trench. Water in the trench does not interfere with the excavation.

The Labbe Digging Machine is built by the Labbe Engineering and Construction Co., of Columbus, Ohio. It is meant for trench excavation and in some ways is rather a distinct type of a trencher. The machine travels on a track directly over the trench. There is a metal frame suspended in the trench under the machine, and this frame running up in front of the machine goes over the top. This framework serves as a track for a bucket, that excavates the earth and carries it up over the machine, dumping it in the rear. The bucket has digging teeth on the lower side and a spout on the upper side, which acts as a chute when the bucket is tipped to be dumped. The whole operation is a very simple one, and the bucket is loaded, elevated and dumped with a single line.

The machine propels itself, and suspended from it are two sets of sheeting put together in a substantial manner, that are used with the aid of trench braces as shoring to make the sides of the trench stand up. The trench is backfilled by the machine for short pipe work, but if it is desired to leave the trench open the excavated material can be placed on either side of the trench. By changing the frame under the machine various depths can be excavated up to 30 ft. A different size bucket must be used for different widths.

There are today on the market a number of trench digging machines. These can be divided into two classes, the first being the endless chain of buckets, while the second has an excavating wheel. It is our desire to give a short description of each and then comment on the general use of such machines. Some of these machines are adapted to digging both trenches and ditches, but for the present we will only consider trench work.

The Hovland Tile Ditcher is sold by the St. Paul Ditcher & Carrier Co., of St. Paul, Minn. This machine, though called a ditcher, is really a trench excavating machine, for it is meant to dig trenches for tile drains which are afterwards covered up.

The machine consists of a series of buckets, knives or shovels, to cut the material to be excavated, supported by a framework mounted on [illegible] on each side and either of which can be raised or lowered at will to level up the machine on sidling ground. The machine is mounted on platform or apron wheels so as to stand up in soft ground, as it is designed almost entirely for excavation in such material. The excavating buckets discharge by a self-cleaning device onto a conveyer consisting of a sheet iron apron, which discharges the material on the side of the trench. Another device keeps this conveyor clean, so that even with very muddy material the buckets and conveyors are kept clean.

Just back of the wheel over which the excavating buckets run is a [illegible] which carries the chute into which the tile are placed. This chute maintains the [illegible] of the trench and prevents earth caving onto or under the tile. The tile is laid automatically by gravity as fast as the trench is dug. It is stated that in a trench 18 ft. deep it will lay from 4 to 12 in. tile at the rate of 75 ft. an hour; 7 ft. deep 100 ft. per hour; 4 ft. deep 150 ft. and 2 ft. deep 175 ft. per hour.

One man runs and operates the machine, a second man operates the [illegible] and a third man keeps the tile [illegible] filled. The machines are made in two styles, the single wheel and double wheel. With a single wheel tile from 4 to 12 in. can be laid to a depth of 18 ft., while with a double wheel 12 to 24 in. tile can be laid.

The Chicago Sewer Excavator is manufactured by the Municipal Engineering and Contracting Co., of Chicago, Ill. This machine is designed for trench digging through any ordinary ground, hard [illegible]. It cuts a trench from 12 to 48 in. in width and up to 26 ft. in depth. The machine is of the ladder type, that is from a heavy steel frame there is suspended a ladder frame with endless chains revolving around the ladder, on which are attached buckets. These buckets on their way up from the trench cut the material, raising themselves and pass the top of the ladder they discharge their load on to a belt conveyor that dumps the dirt on the side of the trench. This conveyor can be placed on either side of the machine or a conveyor can be placed on both sides. If it is desired wagons, carts or cars can be loaded by the excavator and the earth hauled away.

The ladder can be raised and lowered at the will of the operator, and for shallow trenches it is operated at a small angle with the bottom of the trench, but when the trench is deep the ladder hangs more nearly perpendicular. For a trench of a certain depth below the surface the ladder is set for the given depth and if the operator is skilled he can carry this depth approximately throughout. When a certain grade is to be given to the bottom of the trench, the machine should work it possible with the grade, and the operator must so manipulate his ladder so as to be constantly including the depth, if a level ground or where the ground is uneven he must be ready to raise and lower his ladder to conform to the grade.

The frame that carries the ladder runs nearly the whole length of the machine and the entire weight of the ladder is carried by this frame. There are no wheels to run in the trench, but all the wheels that carry the weight of the excavator run on

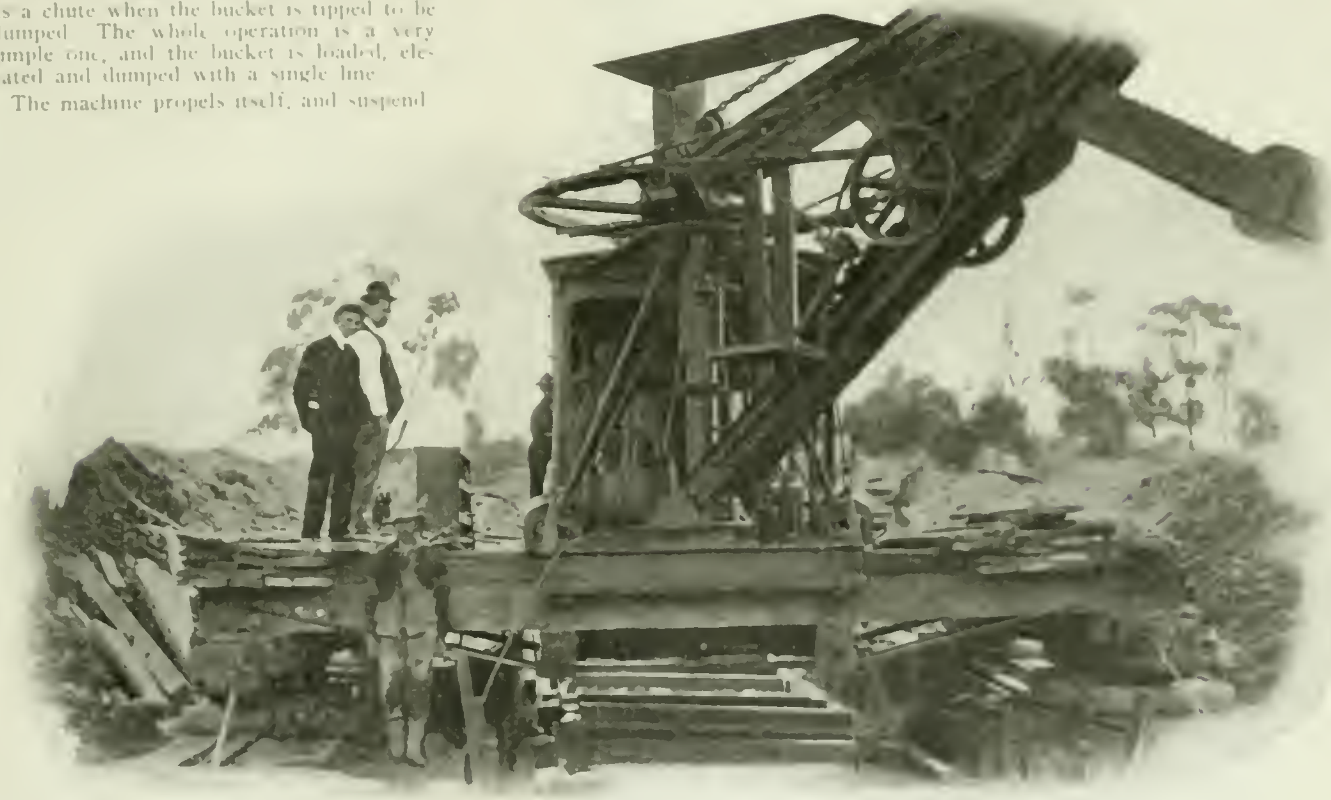

Fig. 2—View Showing Method of Shoring Under a Steam Shovel.

the surface of the ground. The machine propels itself as it is excavating.

The buckets on the ladder are not solid, nor are they known as the skeleton type. Not being solid, they readily clean themselves, but a cleaning device is also provided for the machine. Builders of fair size can be handled by the buckets, without breaking the latter. The cutting action of the buckets and subsequent handling of the material breaks up even plastic clay, so that it is almost pulverized, thus making it easily handled a second time for back filling. The material will handle soft materials and also hardpan and shale. Naturally, it does its best work in excavation that can be classed as average earth. If dry sand is to be excavated from a trench either by any type of excavating trench machines or by hand, it can always be done quicker and more economical by wetting the sand. Upon several occasions, the writer has used this method.

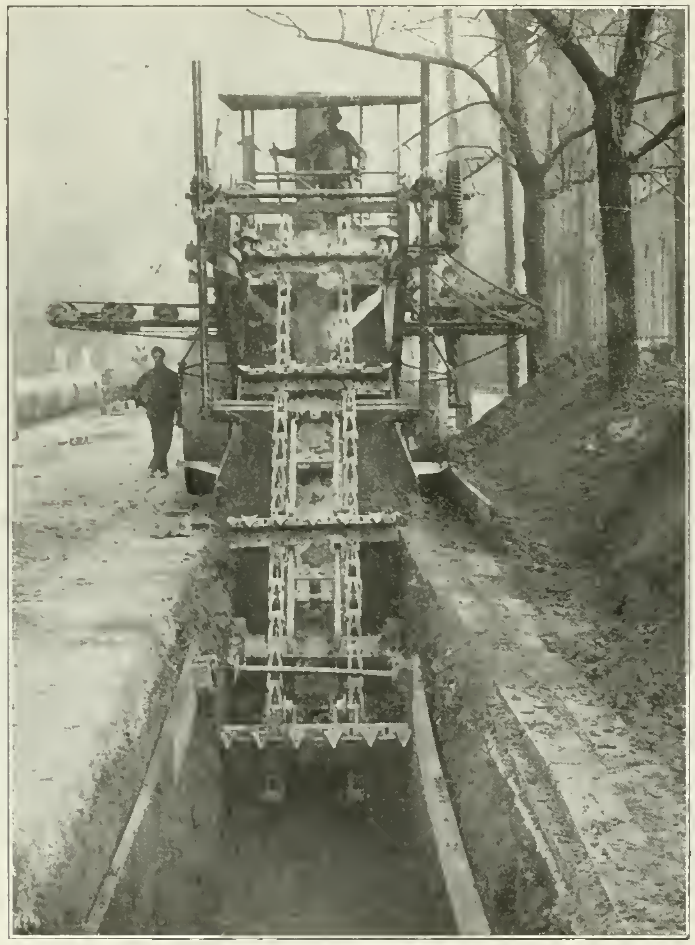

Fig. 3—Trench Excavating Machine Built by Municipal Engineering & Contracting Co.

When pipes and other obstructions are encountered in the excavation running across the trench, the machine can be used to cut right up to the pipe, and over it, and after being raised to pass over the pipe can be put down on the other side, leaving only a small triangular piece under the pipe, to be excavated by hand. Whenever possible, such pipes should be located beforehand and marked, so the operator can readily see where to expect a pipe, but even if this is not done, a careful and experienced operator will be able to tell the instant he encounters a pipe, and he will be able to pass over it without injury to the pipe or the machine. Large builders can be manipulated in the same manner. The operator's position on the machine is such that he can see the work to be done and also that being done.

The excavator travels ahead of the trench so that its weight does not effect the banks of the excavated trench. Shoring, if necessary in the trench, can be placed right up to the machine in the deepest part of the trench.

The machine is made in five different sizes, giving different depths and widths. To change from one width to another, the buckets must be changed on the ladder. A No. 1 machine excavates trenches 14, 19 and 24 ins. up to a depth of 8 ft. No. 1½ makes a ditch from 19 to 36 ins. and 10 ft. deep. No. 1¾ will excavate to a depth of 13½ ft. and from 27 to 36 ins. wide. A No. 2 excavates to a depth of 15 ft. and from 27 to 48 ins. wide. No. 3, the largest machine made, can excavate a trench from 27 to 60 ins. wide and go to a total depth of 20 ft. On the two largest machines, 3 men are used, an engineer, an operator and a fireman. On the other three sizes only an operator and a fireman are needed.

A few years ago several trench digging machines of the ladder type were built by the Helm Trench Machine Co., of St. Louis, Mo. On these trenches there is a vertical ladder and by means of sprocket wheels and endless chains upon which saw tooth buckets are mounted, the buckets excavate the earth, and after elevating it, discharges it into a screw conveyor, which, by means of a chute, throws the excavated material on the side of the trench. The ladder to excavate a 10-ft. trench is 28 ft. long, so that 18 ft. always remains out of the trench. To excavate a deeper trench, the ladder must be spliced. It is to be seen that the limiting factor is that when the ladder is out of the trench, this can make the machine top heavy, although it was believed that a ladder to excavate a trench 30 ft. deep could be handled. To change the width of the trench, the buckets on the endless chains must be changed. The buckets are centered on the chains so the digging edge is near the chain. With a vertical ladder the shoring, when necessary, can be kept close up to the excavation.

The Clark Traction Trencher sold by Willis Shaw of Chicago, Ill., is also of the ladder type. It is built in three sizes, and will excavate trenches up to 60 ins. in width and 20 ft. in depth. This machine is of the ladder type, and the general method of operation is somewhat similar. It is a traction machine, but in digging trenches it is pulled ahead by a cable. A dead man is placed in the ground ahead of the machine and on the port of the excavator is a drum upon which this cable is wound as the machine moves ahead. These machines are not built as massive and powerful as the excavator previously described, and the engines, instead of being placed between the boiler and the excavating machinery, are behind the boiler, thus making necessary fairly long transmission chains, which is always a disadvantage where heavy work is to be done. It would seem feasible to change the position of the engines on the machine.

The ladder is hung from the frame of the machine and is raised and lowered over obstructions in excavating. The buckets have teeth on them for digging. The dirt is dumped on a belt conveyor, which places it on the side of the trench. In changing the width and depth of cut, it is only necessary to shorten or lengthen the chain and move the cutters in or out. Excavated material can be placed on either side of the trench. Two men, an engineer and a fireman are needed to work the machine.

We will continue descriptions of trenching machines, ditchers and our comments on trenches and ditches in other articles.

(To be continued.)

The accident to the canal lock on the Canadian side of the St. Mary's Falls on June 9, closed the Canadian Canal and Locks between Lake Superior and the St. Mary's River for 12 days. Shortly after noon on June 9, the "Perry G. Walker," a freight steamer, bound toward Lake Superior, crashed into the lower gates of the lock at a time when the upper gates were open to allow the manœuvering of the down-bound passenger steamer "Assiniboia" and the freighter "Crescent City." The "Walker" carried away the lower gates and the two vessels in the lock were swept down through it by the flood, receiving considerable damage. After the lower gates were rammed, letting loose the water they held back, the upper gates swung out into the current and were carried away before they could be secured to the wall. The two sets of guard gates and intermediate gates in place were not damaged. The current in the lock after the accident was estimated at 15 ft. per second. The movable dam provided for such contingencies closed across the canal soon after the accident. The canal across which it is to extend is 150 ft. wide and 25 ft. deep, and the water flows through it under a head of about 19 ft. The lock itself is 900 ft. long and 60 ft. wide.

Methods of Excavating Foundations and of Handling Materials by Cableway in Constructing a Reinforced Concrete Arch Bridge.

An unusually large reinforced concrete arch bridge is being built to carry the new 28-mile cut-off of the Delaware, Lackawanna & Western R. R. across the Delaware River. This bridge is 1,110 ft. long and consists of 9 spans, 7 elleptical arches crossing the river and 2 circular arches crossing railway tracks and a highway at the west end. Of the river arches 5 will have spans of 150 ft. and 2 spans of 120 ft.; all river arches will have a rise of 40 ft. The 2 shore arches have spans of 33 ft. each. The bridge crosses the river at an angle of 25° with the current. It is being constructed principally by means of a double-span cableway.

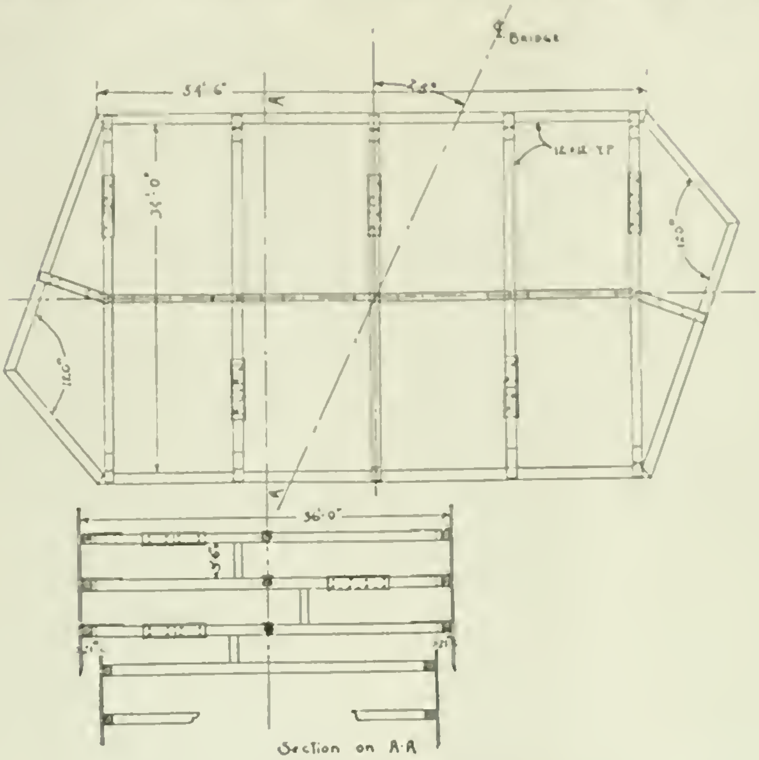

Fig. 1—Bracing for Pier Foundation Pits.

Excavation for Foundations.—The 7 river spans required 6 piers and 2 abutments and only 2 of the piers were in water during low water stages. To get a start on the work while the cableway was being put into position, work was begun on the four piers out of water using derricks. Test borings made by the railway company showed a level stratum of slate underlying the soil at a plane 24 ft. below the river bottom. All piers and abutments were founded on this slate. The excavation ranged from 28 to 42 ft. in depth. Work was begun with pick and shovel, using at each pit a stiff-leg derrick to hoist the spoil and to dump it into narrow gage cars running on a track alongside the piers. As soon as hard material was reached pick and shovel work was abandoned and the derrick was equipped with a Hayward orange peel bucket and the pit was continued down until the sides began to cave, a depth of 8 to 9 ft., when timbering was begun.

The style of timbering employed is shown by Fig. 1. After the pit had been carried down unbraced as far as possible, the bottom was leveled off and a frame of 12x12 in. waling timbers was placed close to the pit floor. Above this and supported on it at 3½ ft. [illegible] blocks a second frame of waling was placed and braced. Outside of this waling frame close sheeting of [illegible] by 10 ft. planks with edges beveled to point away from the pit was placed and as the excavation proceeded was driven down. When a further depth of about 4 ft. had been reached in this way, a third waling frame was placed. Another additional depth of 4 ft. took the full length of the sheeting and another set had to be begun. An offset of 21 ins. was made, a waling frame of correspondingly smaller size was placed and sheeting driven as before. In this way the excavation proceeded to the bed rock. In the deepest pit 42 ft. three sets of sheeting were necessary. The materials were: For the first 20 ft. coarse gravel containing many large boulders; for the next 18 ft. very tough hardpan; and for the final 4 ft. water-bearing gravel.

The water found at the different piers varied. At some it required two 6-in. centrifugal pumps to handle the seepage and at others a 3-in. discharge pulsometer was sufficient.

Cableway Plant.—Most of the concrete and other materials was handled by the cableway previously mentioned. Figure 2 shows the cableway and gives a general view of the whole work. As will be seen, it consists of a double-span duplex cableway. The complete span is 2,085 ft. for each cableway. Under it there are to be 8 piers, two abutments with wing walls, and one concrete tunnel over the N. Y. S. & W. R. R. on the New Jersey side. The bridge also extends over the D. L. & W. R. R. on the Pennsylvania side. Thus work not only had to go on in the river bed and over the stream, but also over two lines of railroad. It was only possible to do this without interference with a cableway.

As stated the entire span is 2,085 ft., but this is divided by an A-frame into two spans, the one on the east side being 865 ft. long and the one on the west side 1,220 ft. long. The towers are of the duplex type and are of sufficient width to make the centers of the two cables about 11 ft. apart. The tower on the east, or New Jersey side is 120 ft. high, while that on the west side is 130 ft. high. Near the center is the A-frame support 75 ft. high, thus dividing the span of each cableway, practically making four cableways. This center frame is of special construction supported on one of the piers, and the main cables, which are 2½ in. in diameter, are secured to the top by means of special castings, making a rigid attachment.

The operating ropes are ¾ in. in diameter, both hoisting and traction lines. The main cables are each about 2,200 ft. long and for hoisting and traction rope there is about 14,000 lin. ft. of line used. The cables are spanned to give clearance to the carriage and material to be handled with the cableway of [illegible] 18 ft. above the completed bridge. Thus high water in the river will not interfere with the cableway, but may interrupt the building of the concrete piers.

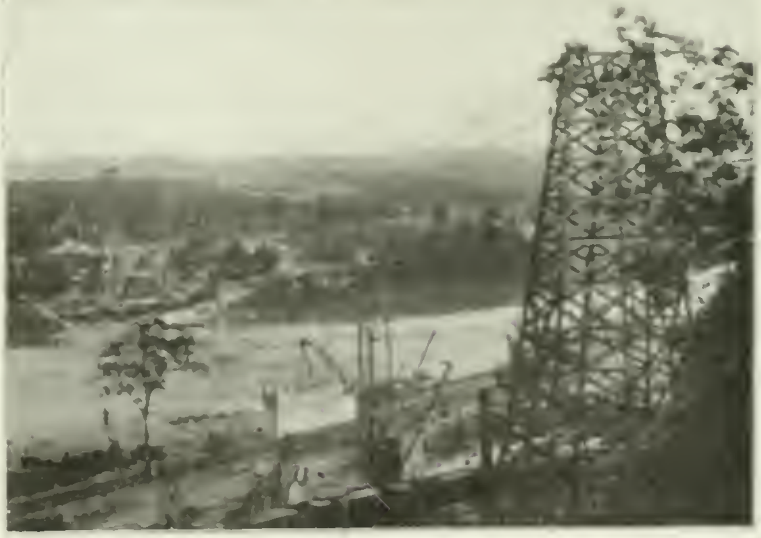

Fig. 2—Double Span Duplex Flory Cableway for Handling Materials.

Each span of the cableway is operated by different engines. On each bank there is a 125 H. P. locomotive type boiler. On each side there are also two 50 H. P. 10x12-in. double-cylinder, double-friction-drum and reversible link motion cableway engines; drums 54 ins. in diameter, 48 ins. long between the flanges. The load operated from each engine is 5 tons, making from 15 to 20 trips per hour. To operate the cableway, four engineers, two firemen and one rigger are required.

With these cableways the foundation work is being done; the concrete is conveyed from the Pennsylvania and New Jersey shores to the different piers in the river, all structural materials are handled and also all machinery such as pumps, etc.

It is stated that the entire work to be done under the cableway will amount to about $1,000,000. The cableway cost from $20,000 to $25,000, thus charging the entire cost of the cableway against the job, it makes only a charge of 2 to 2½ per cent for plant, which is very reasonable for such a large span and for this amount of work.

As stated above, most of the concrete was delivered to the pier on the cableway and dumped direct from the cableway buckets. The remainder was placed by the derrick. It was mixed in a large Smith mixer, situated about 300 ft. from the pier, and was turned out at the average rate of about 180 cu. yds. a day. The labor cost of mixing and placing was a little above 35 cts. per cu. yd.

The contractors for this work are the Smith-McCormick Co. of New York. The cableway was designed and furnished by the S. Flory Manufacturing Co. of Bangor, Pa.

The annual statistical report of the United States Geological Survey on coal mining in 1908 shows that the total production of coal in Idaho in 1908 was 5,429 short tons, having a spot value of $21,832. There are several somewhat restricted and widely separated areas in Idaho in which beds of subbituminous coal and lignite occur, and the coal-mining industry has been confined to comparatively small operations for local consumption. The output in 1908 was 1,079 short tons, or 16.58 per cent less than in 1907, and the value decreased $4,662, or 17.6 per cent. Most of the mining in 1908, as in the three preceding years, was done in the Salmon district in Lemhi county, although small operations were carried on in Bingham and Fremont counties.

According to these returns the total quantity of Portland cement made in Canada in 1908 was 3,495,961 bbls. of 350 lbs. net, as compared with 2,491,513 bbls. in 1907, or an increase of 1,004,448 bbls. or 40.3 per cent. The total quantity of Canadian Portland cement sold in 1908 was 2,665,289 bbls., as compared with 2,436,093 bbls. in 1907, or an increase of 229,196 bbls., or 9.4 per cent. The total consumption of Portland cement in 1908, including Canadian and imported cements, was 3,134,338 bbls. (of 350 lbs. net), as compared with 3,108,723 bbls. in 1907, or an increase of 25,615 bbls., or 0.8 per cent.

A formal beginning of construction work of the canal across Cape Cod was made June 22, when August Belmont of New York turned up a spadeful of earth at Bournedale, Mass., half way across the cape. The first work is to be on two miles of breakwater which is to be built at Sandwich, and within a short time dredges will be put to work. The canal will shorten the distance between New York and Boston 100 miles, and avoid the difficult waters and shoals off the cape.

Roads and Streets Section

Note: This Section is devoted to methods and costs of road and street construction. It will cover road building in all its details, the construction of pavements, sidewalks and gutters, the testing and use of paving materials and the machinery and tools used in road building and paving.

Cost of Macadam Street Work at Easton, Pa.

During 1908 a total of 7,245 lin. ft., covering an area of 13,898 sq. yds. of new macadam streets were constructed at Easton, Pa. The total cost of the work was $6,066.85, or 43.7 cts. per square yard. During the same period 6,662 lin. ft. of streets covering an area of 21,234 sq. yds., were repaired and reinforced at a total cost of $6,375.88, or 30 cts. per square yard. All of the macadamizing was done by the city force, and in his annual report, John McNeal, City Engineer, gives detailed costs of the work. The matter in this article has been taken from Mr. McNeal's report and from additional information which he has furnished us.

Practically all of the new streets were macadamized with limestone to a depth of 6 ins. compacted. The cost of rolling with steam road roller was $4.93 per 10-hour day, a total cost of $1,020.64, or an average cost of 2.5 cts. per square yard of surface rolled. This cost included labor, coal, oil, repairs, etc. The road roller used 44.47 tons of coal, costing $206.86.

The rate of wages and prices of materials were as follows:

Foreman, 25 cts. per hour.
Laborer, 20 cts. per hour.
Road roller engine, 30 cts. per hour.
Two-horse team and driver, 50 cts. per hour.
Team and driver for sprinkler, 50 cts. per hour.
Coal for road roller, $4 to $6 per ton.
Water for sprinkler, 4 cts. per 300 gallons.
Crushed limestone, $1.05 per short ton delivered on street.

In all cases the crushed stone was spread by hand, and screenings were used as binder.

The accompanying table shows the detailed cost per square yard for macadamizing a number of streets with limestone to a depth of 6 ins. compacted measure.

It will be noticed that the cost of spreading the stone in the ten jobs varied from 1.8 cts. per square yard to 3.3 cts., the average being about 2.5 cts. The average cost of sprinkling in the ten jobs was 1.34 cts. per square yard, while the average cost of rolling was 2.5 cts. per square yard.

(1) McCortney St. macadamized for a length of 333 ft. and a width of 30 ft. (1,000 sq. yds.), (2) Lehichton St. for a length of 2,400 ft. and a width of 12 ft. (4,533 sq. yds.), (3) Wood St. for a length of 450 ft. and a width of 30 ft. (1,500 sq. yds.). Wood St. (second section) for a length of 300 ft. and a width of 30 ft. (1,000 sq. yds.). (5) Mulberry St., for a length of 237 ft. and a width of 10 ft. (263 sq. yds.). (6) Davis St., for a length of 730 ft. and a width of 7½ ft. (609 sq. yds.). (7) St. Joseph St., for a length of 300 ft. and a width of 24 ft. (800 sq. yds.). (8) Old Philadelphia Road, for a length of 730 ft. and a width of 24 ft. (1,947 sq. yds.). (9) Nesquehoning St., for a length of 500 ft. and a width of 24 ft. (1,333 sq. yds.). (10) Lincoln St., for a length of 867 ft. and a width of 24 ft. (2,312 sq. yds.).

The ten jobs noted in the table comprise about 15,400 sq. yds. of 6-in. macadam. In constructing this amount of macadam, 3,974 tons of crushed limestone were used. As the average crushed limestone weighs 2,400 lbs. per cubic yard, it will be seen that about 3,312 cu. yds. of crushed stone and screenings were used in the work. The cost of the macadam work proper, omitting the items for grading, drains, etc., for the ten jobs was as follows:

	Total.	Per cu. yd. Loose.
Limestone (3,312 cu. yds.)	$4,173.33	$1.260
Spreading with shovels	375.50	.113
Sprinkling	221.36	.067
Rolling	387.08	.117
Total		$1.557

As it takes about 1.6 cu. yds. of loose stone and screenings to compact to 1 cu. yd., the cost of the macadam per cubic yard rolled in place would be as follows:

	Per cu. yd. Comported.
Crushed stone, 1.6 cu. yds. at $1.26 delivered	$2.01
Spreading, 1.6 cu. yds. at $.113	.18
Sprinkling, 1.6 cu. yds. at $.067	.11
Rolling, 1.6 cu. yds. at $.117	.19
Total per cu. yd. in place	$2.49

It should be noted that the cost per cubic yard for sprinkling and rolling are rather low. The low cost for rolling is explained in part by the fact that, as previously stated, the cost of operating the steam road roller was only $4.93 per 10-hour day.

Method of Constructing Asphalt, Macadam in Lincoln Park, Chicago.

During the early summer of 1908 experiments in laying asphalt and macadam were carried on in Lincoln Park, Chicago. These experiments covered about 80,000 sq. yds. of road surface. Of this 11,000 sq. yds. was laid as a grouted pavement, the fluid being poured hot into the stone, which was subsequently covered with hot sharp sand and rolled so as to form a well compressed mass of mineral aggregate and bitumen. The road was first scarified thoroughly so as to bring the larger stone

DETAILED COST PER SQUARE YARD FOR MACADAMIZING WITH LIMESTONE TO A DEPTH OF 6. IN. AFTER ROLLING.

	(1) cts.	(2) cts.	(3) cts.	(4) cts.	(5) cts.	(6) cts.	(7) cts.	(8) cts.	(9) cts.	(10) cts.
Grading	7.1	....	1.7	....	....	9.6	4.0	....	....	3.6
Picking, leveling and grading	....	2.5	....	....	....	....	....	....	....	....
Limestone	....	....	....	....	....	....	....	....	....	....
Spreading stone	33.9	32.0	25.4	28.8	26.7	30.0	27.1	21.4	23.6	21.7
Sprinkling	2.8	2.8	2.3	3.3	3.1	2.8	1.8	1.8	2.3	1.8
Rolling	1.6	2.0	0.8	1.6	1.1	2.2	0.6	1.3	1.2	1.0
Hauling and breaking spalls	2.4	2.8	2.1	2.6	1.8	4.0	2.4	1.9	2.5	2.5
Drain pipe	....	....	7.5	5.0	....	....	7.3	4.8	4.0	5.9
	....	1.0	....	3.9	....	....	....	....	....	1.3
Total per sq. yd	47.8	43.1	39.8	45.2	32.7	48.6	43.2	31.2	33.6	37.8

in the road to the surface. It was then regraded and rolled lightly, after which a single layer of 2½ in. macadam [illegible] from small material was spread evenly and rolled. The asphalt used was a residuum from the Kansas fields having a specific gravity of .983 at 78 degrees F., and having a total percentage of bitumen of 99.4 and having a loss after heating for seven hours at 325 degrees F. of 11 and a dripping point at 200 degrees F. The material was heated in open top kettles to 300 degrees F. and was applied by hand in specially constructed pouring cans to the amount of 1.6 gals. per square yard. Hot sharp sand was used for the dressing and was spread on the asphalt as fast as the former was poured. Steam rollers followed closely behind and rolled the sand into the asphalt before the binding material became cold. Only sufficient sand was applied to keep the material from sticking to the wheels of the roller. This pavement has been down one year and has been subjected to extremely hard traffic during the winter and spring as well as through the summer months. The surface presents a rubber like appearance, giving off no noise and allowing horses to get a foothold. Automobiles are prevented from slipping even while the pavement is wet. The pavement was laid at a cost of 76 cts. per square yard. The experiments were conducted under the direction of M. H. West, Superintendent of the Lincoln Park System, Chicago, Ill.

Methods of Constructing Roads Over Soft Ground.

One of the annoying problems in country road construction is the securing of a good road bed through swamps and bogs. Such roads are difficult to make and are difficult to maintain because of water under the road beds and because the foundation soil is in most cases a vegetable mould, which becomes mushy and yielding when wet. The following notes have been taken from various sources, from reports of state highway commissioners and from technical papers, etc.

In general some of the methods employed in securing a good foundation for roads over soft ground are as follows:

By draining the subsoil so as to consolidate the ground as much as possible.

Where the soft material is not too deep nor its extent too great, a trench may be dug and filled with solid material to form a foundation for the embankment.

By consolidating the soft material by driving short piles and throwing stone in the side ditches to prevent the muck from oozing to the sides. By filling in with stone or gravel and sand until an embankment is formed resting on the solid ground, and with its top rising to the required elevation.

By distributing the weight over the soft ground by means of brush mattresses, timbers, poles, etc.

By Drainage.—It [illegible] of the natural ground [illegible] by digging wide and deep side drains parallel to the site of the intended road. In the case of bogs it is possible [illegible] moss to condense it [illegible] solid peat. The undrained [illegible] usually consists of about [illegible] per cent of vegetable matter, the remainder [illegible] water. So it is necessary that the drainage be at a gradual rate to avoid carrying off particles of vegetable matter [illegible] ing the sides of the ditches to cave. The side drains are usually carried down to the solid ground, and it is well to cut them in a series of benches so as to expose as large a surface as possible to the influence of the sun and wind. The side ditches are placed about 50 ft. or more from the center line of the road, the distance depending upon the width of the space which is to be left between the edge of the roadway and the side ditches. In no case should the berm be less than 8 ft. and it is better to have it more than [illegible]. Side ditching destroys the [illegible] power of the bog and the drains should therefore be made a considerable distance from the line of the proposed road. Cross drains cut at right angles to the side drains are placed at frequent intervals, in most cases about 50 ft. apart. These cross drains should extend across the site of the intended road and beyond the side drains from 50 to 100 ft.

By Consolidating the Soft Material.—This was done in one case as follows: A county road supervisor was told to construct a corduroy road across swampy ground. Instead he took the logs and drove them endwise beside the road. These logs kept the muck from oozing to the sides and the road proved very satisfactory. The logs were about 16 ft. long and were put down with [illegible] made out of an elm butt, with three handles so that three men could be used on it. In another case a country road superintendent drew cobblestones in the winter time and threw them into the ditch alongside of the road. In the spring the stones sank out of sight. The next winter he threw in more stones. These stones sank some but not out of sight, and as a result he had two walls on either side of the road so that the muck could not ooze to the sides. There has been no sinking of this road since.

Filling in With Solid Material.—This method is often employed in the case of sink holes and for soft places of no great length or depth. In one instance a sink hole about 60 ft. long was filled in the following manner: A crossway above the water level was first constructed of 4 ft. second growth ash poles. On this cobblestones were placed to a depth of 2 ft. and flanked by boulders to hold the dirt. The stone was then covered with gravel to the level of the road on each side of the sink hole.

Another case that came to the writer's knowledge was in the construction of a road across bottom lands and swamps. In this case the road was graded up about 2½ to 3 ft. above the level of ground, but before the stone for surfacing was [illegible] the work the road bed was covered with high water so that it was impossible to travel over it. It was [illegible] that the grade [illegible] so work was commenced [illegible] load of stone was [illegible] the dump [illegible] course. [illegible]

[illegible]

[illegible] The road stood up very well, although it was covered with water several times after it had been completed.

Distributing the Weight Over the Soft Ground.—[illegible]

In another case a temporary road across a marsh of soft muck covered with high grass was built in the following manner: Drift wood was placed along the line of the proposed road, the bottom layer of sticks being placed lengthwise and the top layer crosswise. [illegible] The marsh was [illegible] covered with water from [illegible] to 2 ft. deep. The marsh was covered with wild rice about 8 ft. high, with stalks from ¼ in. to ½ in. in diameter at the bottom. Through the center portion there was an open channel [illegible] wide, which widened out into small pools every few hundred feet. The channel and pools had from 3 to 4 ft. of water and about the same depth of decayed vegetable matter. The turf was about 1 ft. thick with from 2 to 6 ft. of soft black vegetable mould underneath, beneath which was a hard bottom of blue clay. [illegible]

[illegible]

ing surfaced with 5 ins. of gravel. In this case the surface of the bog was drained, care being taken to place the drainage ditches so that they would not impair the sustaining power of the natural crust of the bog.

In another case a road was constructed over a soft, deep, wet and yielding swamp on a raft constructed of long poles. Long poles laid longitudinally with broken joints formed the bottom course, and a second course was formed by poles laid transversely. The two courses were then covered with brush, and on this was laid the earth and surfacing materials. The grade line was kept low and the filling was a clay loam. It may be remarked here that the black vegetable mould from the swamp should not be used for the earth covering. It is better to use clay loam, a gravelly loam, or clay. Sand when slightly moist makes a good foundation material. In some of these roads there has been remarkably little settlement. In the case of one road there was a settlement only of 2 ins. after the roadbed had been subjected to heavy traffic for over a year. The embankment was built over a year. This embankment was built firm peat bog at the elevation of mean high tide, but too soft to sustain a man without sinking in nearly to the knees. The road was 20 ft. wide with a 40 ft. carriageway and the grade line was an incline varying from 4 to 20 ft. above the surface of the marsh. The depth to the hard bottom was 8 ft. below the bog surface. Dry peat was used by George Stephenson to carry the Liverpool & Manchester Ry. across Chat Moss in Great Britain. On the dry peat embankment was placed two layers of bundles to carry the ballast. One of the first railroads constructed in New York state was carried across a swamp by spreading the pressure over a large surface by means of a wooden platform.

In the construction of a short piece of railroad over floating land it was not possible to put in a trestle because the ground was not strong enough to hold the piling. Accordingly small willow brush which abounded along the right of way was cut down and bound into mattresses, which were spread in a uniform binding plan across the right of way. Stringers to support the ties were then laid parallel to the line of the road. Dump cars were next pushed out on this road and by their means sufficient dirt was brought up and spread to allow of flat cars being pushed out on the track with an engine. The fill made in this way had a 2 to 1 slope and in the main the plan was successful, although in some places the roadbed failed to hold.

In Cape May County, New Jersey, a number of roads have been constructed across marsh lands to connect seashore resorts with the main land. These marsh lands consist of large deposits of soft mud, in many cases 25 ft. deep, overlaid by a sod or crust of sedge or grass roots. In many cases this crust is not of sufficient strength to support the weight of a horse. The methods employed in constructing these roads were as follows: A foundation is laid of poles and stringers of sufficient area to support the weight of filling soil and pavement, together with the added weight of travel, without breaking down the meadow crust. The sides of the roadway are protected from wash by curbing and bulkheading on both sides of the road throughout the entire length, and also by a continuous line of mud banks solidly compacted against the outerside of the curbing. In some of the latest roads constructed by the county a "tie" is placed every 8 ft. under the pole foundations at right angles to the center line of the road. These ties are securely spiked or bolted to the piling supporting the side curbing or bulkheading and thus bind the two lines of curbing together, preventing the spreading of the roadway and at the same time carrying a part of the weight of the roadbed to the piling. After the pole foundations are properly laid, good soil is filled in between the lines of curbing until the required elevation is reached, after which shells and gravel are spread over the roadway until the finished surface is brought to an elevation of about 2 ft. above the mean high water level. The pavement that has given good satisfaction on these roads consists of oyster shells spread 5 ins. deep and covered with 4 ins. of good gravel.

Somewhat different methods from those given in the preceding paragraph were used in the construction of a road in Atlantic County, New Jersey. This road was constructed across salt meadows, the mud varying in depths from 6 to 28 ft. The surface along the line of the road was mostly a floating sod, varying in thickness from 2 to 4 ft.; below this was a semi-liquid mud resting upon hard pan. The latter, in a few places, was only 4 ft. thick, and below this was another stratum of soft mud. The first layer of hard pan was depended upon to support the roadway. The approaches to a bridge along the line of the road were piled, a water jet and hammer being used to put down the piles. In driving the piles the first resistance was met at a depth of 28 ft.; at 35 ft. this resistance disappeared and the pile with weight of hammer sank in definitely. Accordingly the piles were only driven to a depth of 30 ft. The pit at this point, however, extended for only a short distance, and in most cases a solid bed of gravel, sand or clay was usually struck at a depth of from 10 to 20 ft. below high tide. Now as to the methods of construction: After the line of road was located sod banks 5½ ft. high, 12 ft. wide at the base, and 2 ft. wide at the top were built. This sod was taken from between the banks and was placed with the grass side out. The inside edges of the sod banks were 60 ft. apart. The space between the sod banks was then filled in with sand dredged from an adjoining bank and pumped through pipes for a distance of one-half mile or more. As the sand settled it pushed the mud sideways until it reached an equilibrium or the sand rested on the hard pan. When the bed of sand was 6 ft. above the level of the meadow its weight was sufficient to displace the mud along the line of the road and a good foundation was secured. There were a number of silt ponds along the right of way of the road and at these points there was no sod for banks. Pine bulk heads were used at these places. After the sand fill had thoroughly settled the roadway was given the proper crown and surfaced with a coating of gravel.

Methods in a way similar to those previously described in this article are sometimes used in Yukon Territory, Alaska, in constructing roads over frozen muck and gravel flats. The ground usually consists of a layer of frozen gravel, next a layer of frozen muck and on this a layer of moss. A bed of 3 in. poles is laid lengthwise on the layer of moss, then comes a layer of brush placed crosswise and on top is broken stone or gravel. The layer of brush is usually 1 ft. thick and the surface of gravel or stone is 6 in. thick. The top width of the road is 16 ft. in most cases. Such a road built over frozen ground costs about $3,200 per mile and can be maintained at much less cost than a road built along hill sides. In constructing roads of this type it has been found best to leave the moss intact under the bed of poles, as it protects the ground from thawing. The black frozen muck, having the consistency of solid stone, remains as a firm bed. The side ditches, usually 3 ft. deep, are cut either entirely in muck or partly in muck and partly in underlying gravel. These conditions vary with the thickness of the muck. The inside faces of the ditch are often banked with sod, thus furnishing an additional protection. In the construction of a side hill road it is necessary to cut into the moss blanket, and as a result the frozen muck is thawed out by the sun and seepage water and becomes a soft, slimy moss. The cost of maintaining such roads has been found to be so much greater than for roads on flat ground, that the latter are now constructed even if the distance between the termini is greater.

The value of the slate quarried and sold in the United States in 1908, as reported to the U. S. Geological Survey, amounted to $6,316,817, an increase of $297,597 over the value of the 1907 output—$6,019,220—in spite of the general business depression which prevailed during the later year. This increase was in the production of slate for roofing, most of the slate quarried in this country being used for that purpose. In 1908 the quarries yielded 1,333,171 squares of roofing slate, having a total value of $5,186,167 and an average value of $3.89 per square. In 1907 the roofing-slate output was reported at 1,277,554 squares, valued at $4,817,769, or $3.77 per square. The increase in the output of this material in 1908 was therefore 55,617 squares in quantity and $368,398 in value. The value of the slate quarried for other uses—such as blackboards, school slates, flooring, sinks and laundry tubs, sanitary ware, table tops, mantels, and hearths—decreased from $1,201,451 in 1907 to $1,130,650 in 1908—a loss in value of $70,801. The states producing the largest amount of slate are Pennsylvania and Vermont. Pennsylvania, whose output in 1908 was valued at $3,902,958, furnishes more than half of the roofing slate and of the milling stock and is the only state reporting a production of blackboards and school slates. About one-fifth of the milling stock and more than one-third of the roofing slate were quarried in Vermont, whose output in 1908 was valued at $1,707,616. The other states producing slate in 1908 were Maine, whose output was valued at $213,707; Virginia, with an output valued at $194,356; New York and New Jersey, with an output worth $133,494; Maryland, which contributed $102,186 to the total value for the country; California, whose production was valued at $60,000; and Arkansas, with an output valued at $2,500. But little slate is imported into the United States, and the exports, which reached a considerable amount during the strikes in the Welsh quarries, have decreased so that they are unimportant as compared with the total output.

The last of the steel towers which form the piers for the bridge at Lethbridge, Alta., on a part of the Lethbridge-McLeod cut-off of the Canadian Pacific Ry. has been completed. The structure will be 312 ft. high at its highest point, one mile and 47 ft. long, and will rest on 67 steel piers with a natural rock foundation. In its construction 24,000,000 lbs. of steel will be used. The entire work is to be completed in August. Its cost is $1,500,000.

Unclassified and General Articles

Note: This section is devoted to methods and cost articles on construction work not properly coming under any of the preceding classifications.

Engineering Responsibility.*

Few fields of study are more fruitful of results and lead to more genuine progress than a study of the causes of failures. In our studies of failed and broken parts in connection with our work at Altoona for now some years, we have been gradually led to ascribe failure to one or more of the four following causes, viz., to bad material, bad workmanship, bad or faulty design or to unfair treatment.

First, bad material. This does not cover those cases where the wrong kind of material was used or material not adapted to the work. If cast iron is used when steel should have been employed, if the steel is brittle when the service requires tough, tenacious metal, this is no fault of the material. Failures due to the employment of material unfitted to the service come under another category. Nor can the material be blamed if the size of the part which fails is too small. This cause of failure also comes under another category. But material is bad, and may justly be charged with being the cause of failure when it is different from what those who put it in service had a reasonable right to expect it to be. A rail with a bad pipe in the head, an axle made from a badly segregated bloom, a piece of concrete in which the materials are improperly mixed or contain not enough or inferior cement, are all examples of bad material, and if failure comes the failure may justly be charged to the material.

Why does not the producer always furnish good material? Our experience on this point has brought us face to face with several explanations of the difficulty we are considering. First and perhaps most important is the price. It is constantly urged that the consumer will not pay the price requisite to secure the materials desired. No information is usually given as to how far the wished-for price, requisite to secure such good materials as the producer would like to furnish, covers a desire for large profits, and consequently consumers have already been a little slow in attaching much weight to this excuse. Prices are largely determined by competition, and in the absence of something more than a verbal statement from the producer that better materials would be furnished at a higher price, he would be a bold purchasing agent that would pay the higher rate. On the other hand it is undoubted that competition is the antagonist of quality, and where materials are bought without reasonable specifications rigidly enforced there is unquestionably much weight in the contention of the producer.

Another reason or excuse for poor materials is that processes and methods of manufacture do not always and every time yield the desired first quality product. Strive as the manufacturer may, the works always turn out some material that is inferior.

Another and most pernicious excuse for furnishing bad materials is the attempt so common everywhere on the part of producers to usurp the legitimate functions of both the consumer and his expert. This manifests itself in the statement so commonly made by those furnishing material, that it is good enough for the purpose, thus arrogating to themselves the right to decide not only how the material shall be made, but also what kind of material the consumer and his engineer shall use. Pernicious though this custom may be a good deal may be said in palliation of it. The practice is the outgrowth of an historical situation. In the earlier days when the consumption of materials was only a fraction of what it is at present the producer of any material was supposed to know not only how to manufacture it but also its characteristics and how it would behave in service, and consequently consumers who in those days had scarcely begun to study for themselves the behavior of materials in service, naturally turned to the manufacturers for counsel as to what materials to use. This practice is still in vogue, and it is to be confessed that where it is employed, no legitimate criticism of the producer can be made if he urges that the material is good enough for the purpose. On the other hand, as time progressed, and large consumers began to study for themselves the behavior of materials in service, as they began to employ their own experts, as testing machines and laboratories began to increase, as, indeed, a society for testing materials came into existence and knowledge of the properties and characteristics of materials began to widen, it is evident that the situation has changed and that where materials are bought on definite specifications, the voice of the producer as to quality is no longer potent, and that the old excuse for inferior materials, that they are good enough for the purpose, is no longer entitled to consideration or weight. We are entirely ready to allow that the study of materials during both the process of manufacture and their behavior while they are in service, is a legitimate field of activity for both producer and consumer, and, as is well known, we have persistently urged with all the force that we were capable of that while specifications are being made there should be the heartiest co-operation on the part of both, but the specification having been decided on and the contract placed in accordance therewith, there really seems to be very little room left for excuse for furnishing materials that do not meet the requirements because they are, in the judgement of the producer, good enough for the purpose.

We intentionally refrain from discussing that excuse for poor materials which has its foundation in an overweening desire to make money, since it is so clear that the producer who does not give a reasonable equivalent for the money that he receives must necessarily have a short business life.

Coming now to the second cause for failure in structures, bad workmanship. That bad workmanship is a far too frequent cause of failure is common experience. The tendency to slight the job is almost universal. A rivet or a bolt is left out, with consequent unexpected strain on those which are actually put in, a forging does not fill out the pattern, or the metal is burned, or a weld is defective.

Those of you who have frequently been brought into contact with the results of bad workmanship have no doubt, like myself, often wondered why work was so badly done. Not infrequently in contemplating a failure in which bad workmanship played an important part we have said to ourselves, "Good men evidently not careful." And yet, since workmanship is so important an element in our theme, it may not be amiss to go a little deeper into the matter. [illegible] lack of skill, general indifference and simple plain laziness are important elements in bad workmanship. But since these are individual characteristics it probably would not yield any valuable results to discuss them. It is true the apprentice system or lack of apprentice system, which is characteristic of many trades might, perhaps, justly be blamed for lack of skill. But it would lead us too far to consider this point.

No doubt many will claim that inferior or insufficient compensation is the most fruitful cause of poor quality of work at the hands of those who, in our industrial system, play the part of hewers of wood and drawers of water. But if we are right, the experience of the last few years has not seemed to confirm this view. If this was the real explanation it would seem to necessarily follow that voluntary increase in wages would bring an increase in efficiency. On the other hand, if we may trust the information that we have been able to gather, the increase in efficiency following voluntary increases in wages has been most disappointing. We must apparently look further for the real reason for poor workmanship.

In our judgment, the method of compensation for work performed has a direct and most important influence on the quality of the service rendered. We refer especially to the piecework system in those places where it is rigorously used, and to the payment of all interested in proportion to the amount of successful output, which is so common in the steel industry. Both these methods of compensation stimulate output at the expense of quality, and it is not at all strange, perhaps, that after constructions have found their way into service, we should not infrequently find evidences of the haste, the hurrying over, and the inferior workmanship which these methods have necessarily done so much to stimulate. We are not at all prepared to suggest any substitute for them and we are and have been for many years an advocate of them from the standpoint of successful management, but it is folly for us to close our eyes to the fact that the piecework and kindred successful output methods of compensation of workingmen are antagonistic to quality of work, and that, despite all our efforts to the contrary, they may justly be held responsible for some of the engineering failures.

One more phase of the workman problem. Close observers of the modern workman have noticed for some years a growing tendency on his part to manifest less and less interest in his work. [illegible] pride in his work and a genuine feeling of loyalty and devotion to the establishment of which he forms a part are gradually becoming less and less. The allegiance of the workman, under [illegible] which now pervades our whole industrial system, is gradually passing over, in a measure at least, to the labor organization; instead of co-operation, there is [illegible] antagonism. Instead of zeal and earnestness on the part of the workman to do his best there is steady fight to make the organization stronger [illegible]. The effect of this transfer of allegiance on the quality of the work performed needs no elucidation.

It is not at all our purpose to discuss the labor problem, and this statement of the situation is made only because it throws a valuable side light on the question we are considering. We may, however, be permitted a single statement, viz.: We are firmly convinced that if labor organizations would devote less time and energy to contention with employers and more effort toward making the organization stand for skill and plain, simple honesty in workmanship, and for fair dealing with, and reasonable devotion to, the interests of employers, all questions connected with the recognition of the union would fade into insignificance and collective bargaining would be welcomed, nay, even, sought for, by those who are managing the great industries of our modern civilization.

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*Presidential address delivered before the American Society for Testing Materials, on June 29, by Dr. Charles B. Dudley.

Third, it is evident that the engineer who makes or finally decides upon the design of any structure carries a heavy load of responsibility. He is first in the field and practically tells all who follow what is to be done. He must decide not only the kind of material that is to be used but also the amount or sizes, and how it shall be disposed. His realm embraces every kind of structure, from the foundations of a bridge or building to the most minute detail of a locomotive or car. In railroad track he says or should say what weight of rail shall be used, the number of ties per rail, and the kind and depth of ballast. His knowledge of the properties of materials used in construction must necessarily be broad and comprehensive, and the field is so enormous that there are naturally numerous specialists, each being able to cover, and be an authority in, only his own little paddock.

The engineer who makes the design labors under two very serious difficulties. First, it is not possible, many times, to compute the strains to which the whole or parts of the structure will be subjected. Perhaps we can make this point clear best by considering the locomotive driving axle. The strains produced, when we regard the locomotive as a vehicle, are simple and easily determined. So likewise the bending moment produced by the action of the steam on the piston, as well as the torsion strain produced by the crank. But who can tell the bending moment produced by the lurch when the wheel strikes a curve at high speed? Who can even give a guess at the strain produced when the brake is applied, making an emergency stop at sixty miles an hour? Moreover, the tendency of the times is toward larger and larger structures. And as the parts increase in size, would any of us be willing to say that the strains in each part would increase directly proportional to the increase in size of the whole structure, or that a proportional increase in size of any given part would so successfully meet the increased strains as did the corresponding smaller parts of the original structure? The engineer who makes the design, perhaps more often than any of us, is at the end of his knowledge, and if failure comes due to defective or faulty design deserves, in our opinion, more sympathy than any one else involved.

But the designer labors under another serious difficulty. He is often overruled and prevented from doing what his judgment prompts him to do, in the interests of safety, by those who control expenses. The construction he would like to use costs more, and the management for economic reasons demands something less expensive. Of course, under these conditions, much responsibility is taken off the designer. And while we are ready to allow that some check is desirable, since those who make the design are, after all, human and naturally will take care of themselves, we cannot but feel this check should be sparingly applied in all places where safety to human life is involved.

Fourth, unfair treatment. As already indicated, there is a natural disposition on the part of each of us to relieve ourselves from blame and put the fault on some one else, and if our observation is worth anything there is no field of parceling out deserts among those involved in failures and the responsibility therefor more fertile than this one of unfair treatment. This field is the especial paddock of the maker or producer of material. If a rail breaks or fails in service there was, says the rail maker, something wrong with the track or with the locomotives or cars that run over it. If a car wheel breaks or fails to give the guaranteed mileage, the track was too rough, the use of the brakes too severe or the lading too heavy, and so on. Far be it from us to say that unfair usage is not many times a legitimate explanation of failures. If a freight locomotive, designed to haul a heavy load at twenty miles an hour is used at times on a passenger train at forty miles an hour, and in so doing shakes herself to pieces, the fault is certainly not in the materials nor in the workmanship, nor in the design, but in the unfair use. If, due to the growth in size of locomotives and cars, an old iron bridge, designed for not over two-thirds the live load which is actually put upon it, gives way and produces a disaster, the responsibility rests with the operating officer rather than with the bridge engineer. These examples might be multiplied to almost any extent, but perhaps enough has been said to make the point clear.

There is, however, another phase of this part of our subject. Unfair treatment is very much broader than the obvious misuse of a bridge or of a moving vehicle. The materials entering into a structure may be unfairly treated. If the calculated strains are too high, or, what amounts to the same thing, too low a factor of safety is employed, materials are unfairly used. Still further, where a structure is a composite it may, and undoubtedly does, often happen that the elements making up the composite are unfairly treated, as when, for economic reasons, not enough money is spent to properly install the structure. For example, a steel rail called upon to do its work supported by too few ties, insufficient ballast and a badly drained sub-grade, is unfairly treated. Moreover, the state of repair in which structures are maintained is clearly an element in their fair treatment. If not enough money is spent in repairs and parts become weakened by decay, corrosion or wear to such an extent that failure results, it is entirely obvious that the failure must be attributed to unfair treatment.

We have gone thus quite at length into detail in what has preceded in order that we might have definitely before us the elements entering into this problem and be able to see more clearly where truth and justice lie between the conflicting interests. If now our analysis of the causes of failure is accepted as correct, it is evident that freedom from failure in construction depends on the conscientious and intelligent action of four different contributors to the final result. The materials employed must be conscientiously and intelligently made, and must be what they are supposed to be. The workmen who use these materials must do their work conscientiously and under intelligent guidance. The engineer who designs the structure must have abundant knowledge of the properties of the materials he is using and must take as little as possible for granted in deciding on shapes, sizes and kind of materials to be employed. And, finally, the one who installs and operates the structure, when it is completed, must keep it in proper repair and look well to it that no duty is required of it which subjects it to unfair strains.

It is likewise evident that, since the four parties involved in successful construction have different individualities and may have diverse and even antagonistic interests, there is abundant reason why there should be an attempt to shift responsibility for failure. And, indeed, we might perhaps safely go a step further and say that there is abundant reason why each of the four parties should try to limit the part which his own work plays in the final result, and say plainly, if the other three had done as they should there would have been no failure. The man who furnishes the material is tempted to say, "If the designer had allowed a proper factor of safety everywhere, if the workmen had done their duty, and if the structure had received only proper fair treatment, almost any material would have been good enough." The engineer who makes the design is tempted to say, "if the material had been what I had a right to expect it to be, if the workmen had done good work and there had been no abuse of the structure in service, there would have been no failure." And so on, for the others. It is plain that the problem of obtaining successful constructions is a complicated one, and that the chances for divided responsibility which are involved are no small element in this problem.

But perhaps we have said enough in analysis of the causes of failure. Let us now devote a few moments to precautions that may be taken with material and workmanship in the interests of safety; and to a consideration of what should be our mental attitude toward design and unfair treatment. And first as to workmanship. Under present conditions the necessity for close supervision is evident. Managing men everywhere recognize this necessity and are employing all means at hand to secure it. We knew an officer of a large corporation some years ago who said to his board of directors: "If you will allow me to spend $50,000 a month more in salaries, so that I may give your work better supervision, I will give it back to you four-fold." Moreover, with the growth of modern industry and especially with the development of machinery as an element in this growth, the individuality of the workingmen has necessarily diminished, and the present industrial ferment of strikes and lockouts, with their accompanying riots and violence, is, as we interpret it, the revolt against this debasement of individuality. That the revolt should at times go too far, that unreasonable demands should be made, that demogogues and agitators for their own advancement should get into positions of, prominence, is perhaps to be expected. As time progresses these will pass. It takes time to bring a change of views in both employed and employers. Already there are signs of something better and our belief is that in the not far distant future, as the result of wiser management on the part of labor organizations and reasonable concessions on the part of employers, there will be a return by the workingmen to the old-fashioned virtues of interest and pride in their work, and unswerving loyalty to the organizations which they serve. The effect of this change on the quality of workmanship needs no comment.

Second, with regard to material. It is difficult for us to see how any one who is responsible for safety in structures dare at the present time put material into these structures which has not been bought on carefully prepared specifications and which, before acceptance, has not been rigidly inspected and tested. In time past, before consumers understood the demands which the service makes on materials, the reputation of the maker was perhaps the best safeguard known for good materials and was accepted as reasonable defense in the investigations following disaster. But in these days, when the service has been so frequently questioned, when so much accumulated information is available, when experts and facilities for testing are so largely multiplied, we cannot help feeling that the management that puts materials into service, especially where safety is involved, without careful and conscientious inspection and testing, is taking a risk that it is no longer entitled to assume. It is gratifying to be able to see that, as the years go by, there is constant and steady growth in this field. And while the ground is still far from being covered and the number of standard specifications still far to small, each year brings some progress, some steps forward.

Third, bad workmanship and bad materials can apparently be so controlled as to secure safety by sufficient supervision and by having proper specifications, with rigid inspection and test. But how about the unfair treatment of materials, or the structures made from them? Here no supervision beyond some meager legislative enactments and the condemnation of public opinion in case of disaster is possible. It is, of course, true that those in charge of the construction and operation of utilities in which the public safety is involved are constantly face to face with the possibilities of heavy losses in the way of damages for accidents, and no doubt this is a most powerful check against unfair treatment. But it has seemed to us for a long time that the producers of material have far too much neglected their opportunities. Surely it is as legitimate that the producer should study the treatment his material gets in service as that the consumer should study the methods by which the material is made. It may take the consumer a few years to become familiar with the idea of being told that he has not treated material fairly, since he is undoubtedly accustomed now to thinking that he can do what he wishes with what he has bought and paid for; but we are confident there would have been fewer complaints of material in the past if the method we have suggested had been in vogue. It is, of course, not to be understood that we are recommending howls about unfair treatment as excuses for inferior materials. What we have in mind is that careful studies and investigations should be made by the producer, leading up to demonstrations if possible. It is common experience that the truth is reached with much greater certainty and speed if a problem is attacked by two parties who approach it from different standpoints and are actuated by antagonistic interests. Our whole Anglo-Saxon jurisprudence is founded on this method of procedure.

Fourth, what shall we say of the engineer who makes the design? We have already described his difficulties, pointed out his limitations and expressed our sympathy with him in his chance failures. It remains to put on record a few thoughts which have forced themselves on us, not once but many times, while preparing this paper, as especially when contemplating the difficulties of the engineer who makes the design. The truth is we are using materials in construction without sufficient knowledge. There is crying need for experiment. Testing machines, adequate to [illegible] [illegible] that we have used material wisely and economically. The factor of safety [illegible] where is largely a guess. The late A. J. [illegible], one of the brightest [illegible] engineers in this country twenty [illegible] years ago used to speak of the [illegible] factor of safety, one half of which is a factor of ignorance. We cannot help feeling that no better use could be made of some small fraction of the millions that have been accumulated by individuals in connection with our great industries during the past half century than in the establishment of a Bureau of Engineering Research. Who will avail himself of this magnificent opportunity?

Just a word in conclusion. No one, I am sure, can contemplate the situation which we have been trying to discuss without being impressed with the diverse and ofttimes antagonistic interests involved. The producer of material is anxious to secure the largest amount of successful output and the greatest possible amount of reward therefor. The consumer wants to limit this by restrictions as to quality and to obtain the material at the lowest possible figure. The workman's interest is to secure the maximum of pay for the minimum of effort, and in this struggle it may perchance happen that the quality of work suffers. The employer's interests are clearly the reverse of the workman's, and so on. The foundations of these diverse interests are of course very deep, and with the present organization of society it is not easy to see how they are to be obliterated or their antagonism neutralized. But we beg to make one suggestion. Would not an infusion of genuine conscientiousness into our industrial life bring an amelioration? If a little less energy was expended in the mad race for wealth and a little more zeal manifested in maintaining the rugged virtues of honesty, integrity and fair dealing, would not some of the friction and contention of our present commercial life disappear? We must get on together, and surely harmony is better than contention. There are some things in life of more value than [illegible]

Prices of Tools and Materials in 1907 and 1908.

In 1902 the U. S. Bureau of Labor issued its first bulletin relating to the wholesale prices of the principal staple commodities sold in the United States. Every year since a bulletin has been issued showing actual prices for the year immediately preceding and relative prices for the period since 1890. In our issue of May [illegible], 1907, we printed a table showing the average yearly prices from 1890 to 1906 [illegible], and in this article we give the actual prices for 1907 and 1908, the latter being taken from the recently issued bulletin.

In the recently issued bulletin prices are given for 258 articles, and the [illegible] shows that wholesale prices [illegible] these commodities as a whole receded from the high level of 1907, which was the year of highest prices in the period 1890 to 1908. The [illegible] of 1908 carried prices back approximately to the level of 1906. The average for 1908 was [illegible] per cent below that for 1907, [illegible] per cent higher than for 1906, and [illegible] per cent higher than for 1897, the year of lowest prices for the period 1890 to 1908.

The 258 commodities considered by the Bureau were divided into groups as follows: [illegible] principal decrease being in the price of cotton goods and silk. The fuel and lighting group decreased in price [illegible] per cent, although petroleum increased in price, as did also many kinds of coal. The drugs and chemical group increase in price in 1908 over 1907 was [illegible] per cent, the articles showing the greatest increase being glycerin and alcohol. In the [illegible] group there was a decrease of 5.7 per cent, the greatest decrease being in the price of jute, rope, rubber, etc. But the greatest decrease was in the group containing the articles most used by contractors—namely, the metals and implements group and the lumber and building materials group, the decrease in the case of the former being 12.6 per cent and in the case of the latter 9.1 per cent. Of the [illegible] articles included in the metals and implements group there was a decrease in price for [illegible] articles, including copper, iron, lead, [illegible] nails, tin plate, etc. Ten articles, including steel rails, did not change in price and in only one article, quicksilver, was there an increase in price. In the lumber and building material group [illegible] of the [illegible] articles decreased in price in 1908 as compared with 1907. Nearly all kinds of lumber products showed a marked decrease in price as did also brick, window glass, [illegible] turpentine and putty, [illegible]

The following table shows the average wholesale prices for certain tools and materials for the years 1907 and 1908. The [illegible] quoted are mostly the prices in the New York market [illegible] Washington, N. [illegible]

Tools.	1907	1908
Augers, [illegible]	$[illegible]	$[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
Hammers, Maydole No. [illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
Materials.		
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
Hemlock, M ft.	[illegible]	[illegible]
Lead, pig, [illegible]	[illegible]	[illegible]
Lead pipe, [illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
Maple, hard, M ft.	[illegible]	[illegible]
Nails, cut, [illegible]	[illegible]	[illegible]
Nails, wire, [illegible]	[illegible]	[illegible]

* [illegible]

Oak: white plain, M. ft.	55.208	49.292
Oak: white, quartered, M. ft.	80.000	80.167
Pine: yellow, M. ft.	30.500	30.500
Pine: white boards, No. 2 barn, M. ft.	37.417	36.375
Pine: white boards, uppers, M. ft.	97.083	96.083
Rope: manilla, ⅜ in., lb.	.129*	.101
Shingles: cypress, M	4.225	3.537
Shingles: red cedar, 16 in., M.	2.696	2.012
Spruce: M. ft.	24.000	20.792
Steel rails: ton	28.000	28.000
Tar: bbl.	2.329	1.600

The following table shows the average prices of Portland cement, natural cement and steel rails from 1890 to 1908 inclusive:

Year. Average.	Portland cement, domestic. Per barrel.	Rosendale cement. Per barrel.	Steel rails, per ton.
1890-1899	*$1.9963	$0.8871	$26.0654
1890	......	1.0542	31.7792
1891	......	.9417	29.9167
1892	......	.9688	30.0000
1893	......	.8875	28.1250
1894	......	.9271	24.0000
1895	1.9688	.8521	24.3333
1896	2.0000	.8333	28.0000
1897	1.9667	.7521	18.7500
1898	1.9979	.7604	17.6250
1899	2.0479	.8938	28.1250
1900	2.1583	1.0167	32.2875
1901	1.8896	1.0188	27.3333
1902	1.9500	.8646	28.0000
1903	2.0292	.8896	28.0000
1904	1.4604	.8021	28.0000
1905	1.4271	.8333	28.0000
1906	1.5750	.9500	28.0000
1907	1.6458	.9500	28.0000
1908	1.4600	.9500	28.0000

*Average 1895-1899.

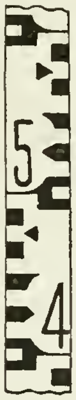
Field Methods in Making Topographical Surveys for the Katskill Reservoir for the New York Water Supply.*

Topographical plans of the reservoir sites were required for the determination of the location of the dams and dikes, the relocation of highways and railroad, the capacities and limits of the reservoirs, and as an aid in the solution of other problems involved in construction. The extent of the areas to be mapped and the necessity for an early completion of the surveys made necessary the use of methods which would insure the prosecution of the work with a degree of speed which was limited only by the accuracy deemed desirable. The topographical surveys were made by stadia with sufficient care to locate very closely the 5 ft. contours, buildings, roads, streams, ledge outcrops, swamps, woodland, etc. The surveys of the Ashokan basin on the Esopus Creek were mapped on a scale of 100 ft. to the inch, and those in the Rondout and Vernooy valleys on a scale of 200 ft. to the inch.

The field parties consisted of an assistant engineer in charge, an instrument man, a recorder and four or five rodmen and axemen. In the very thick woods it was impossible to use more than two rods to advantage, with two men clearing sights, while in the open it required the services of four rodmen to keep the observer busy. The transits used were of standard makes, with horizontal arcs graduated to 20 seconds and vertical arcs reading to minutes. It was found of advantage to have the vernier on the horizontal arc facing the observer rather than on the side, thus enabling the azimuth to be read without the observer shifting his position. An inverting eye piece was used to obtain the best definition possible. The rods were of straight-grained white pine, about 14 ft. long, and weighed about 10½ lbs. In cross section they were 4x⅝ in., with a stiffening rib 1¼x¾ in. screwed on the back. The ends were protected by ⅛x⅝ in. iron straps which extended about 5 ins. up the edges of the rod. These rods were made in a local carpenter shop and were painted by the rodmen in spare moments. Black characters on a white ground were used. Field tests were made of various types of graduation by a committee composed of division engineers from the Northern Aqueduct and Reservoir Departments, and the form shown in the accompanying sketch was adopted as being the most effective.

No difficulty was experienced, under ordinary conditions, in reading distances to the nearest foot on sights up to 1,000 ft. Axes, brush hooks and machetes were used for clearing lines. The brush hooks were found most effective on vines and undergrowth, and the machetes on saplings and brush.

The field notes were kept on 5x8-in. loose leaves, the standard size for all field notes of the Board, the notes for a day's work being sent to the office each night. None of these loose leaves have been lost. All directions were given by azimuths which read from the north clockwise. The distances as read by the instrument men were corrected by the use of correction diagrams based upon observations made by placing the rod at measured distances from the instrument, the observer reading the distances intercepted by the stadia wires in the particular instrument which he was using. The observer's personal equation was thus established with that instrument in the regular stadia work. At least four sets of observations were made, the object being to obtain readings under different atmospheric conditions in order to develop a good average correction curve.



Stadia Rod.

In order to distinguish the points placed by the topography parties from those of the real estate parties, 2x2x14-in. oak hubs were used for the instrument stations. The The points were marked by indented galvanized iron tacks driven in the hubs, and 1x16-in. white pine stakes 2 ins. wide at the top and tapering to ⅜ in. at the bottom were used for witness stakes. The designation of the station was cut in the witness stake with a timber scribe. For purposes of identification, each traverse was given the initial of the chief of party and a letter. The stations were numbered in each traverse consecutively from *1* to *n;* thus, *S-B-5* was the fifth station in Smith's second traverse. On reaching the *Z*th traverse, an extra letter was used and the alphabet again run through, thus *S-A-A-4*, *S-A-B-7*, *S-A-C-3*, etc., and *S-B-A-3*, *S-B-B-5*, etc.

Each traverse began at a station in the triangulation system or in a previously completed traverse, and closed on a point in the triangulation system, another completed traverse or upon itself.

A station being completed, the vernier was set on the azimuth of the back sight. Sights for line were taken on the edge of the rod which was set directly over the point. The middle cross hair was set on the height of instrument and the vertical angle read. The distance was read twice, once setting the lower cross hair on an even foot and once setting the upper cross hair on an even foot, all three wire intercepts being noted each time. A similar procedure was followed at the forward station, consequently the distance between main traverse points was observed four times and the vertical angle twice. The magnetic bearing of the traverse lines was read as a check on the azimuth observations. It was customary to set the forward traverse points before taking side shots in order to eliminate any errors due to a possible slight movement of the instrument during the taking of topography at a station.

Elevations were carried by stadia, a back sight being taken upon a point of known elevation. To determine the height of instrument above the point, one of the tripod legs was graduated to half-tenths of a foot in such a manner that when the plumb-bob, which was adjusted so that the point just touched the hub, was swung over against the tripod leg, the reading opposite the plumb-bob point was the height of the instrument above the stakes.

For the side shots taken from a station, the upper and lower stadia wires only were read and the middle cross hair set on the height of instrument to obtain the vertical angle. In case the view was obstructed in the latter instance, the cross-hair was set at an even number of feet above or below the H. I. and the fact recorded in the notes.

In view of the fact that the surveys were made, notes taken, computations made, and the results plotted by different individuals, it was necessary, in order to avoid confusion and mis-interpretation of the notes, to establish a more or less uniform method of procedure. The following symbols and abbreviations were used in the field and office work to economize time and produce uniform results:

Each rodman kept a slip of paper tacked on the back of his rod, on which the number of the shot and the object was noted. The recorder noted the azimuth, stadia reading, vertical angle and the shot designation, the latter being the rodman's

North	N	Barn or Shed	Bn		
South	S	Privy	Py		
East	E	Well	Wl		
West	W			Cemetery	Cem.
Center	*C*	Azimuth	Az	Brook	Br
End	Ed	Elevation	El	Railroad	R. R.
Edge	Eg	Bench Mark	B. M.	Highway	Hw.
Side	Si	Contour Point	C. P.	Private Road	Rd.
Top	T	Ledge Outcrop		Bridge	Bge
Bottom	Bt	Cliff	Clf	Telephone Pole	Tf
House	Ho	Quarry		Telegraph Pole	Tg
Corner	C	Quarry Dump	Q. D.		

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*Extracted from a paper by J. S. Langthorn read before the Brooklyn Engineers' Club, Jan. 9, 1908.

initial and sheet number. At the end of each set up the sheet numbers of the rodmen were checked by the recorder to avoid errors. The rodmen's slips were turned in each day with the field notes.

The allowable limits of error in the field work were as follows:

Closing error in azimuth—not greater than 10 seconds per station.

Closing error for elevations not greater than $0.2\sqrt{L}$.

Closing error in distance not greater than $1.00\sqrt{L}$.

L = length of traverse in thousands of feet.

The majority of the traverses closed well within the above limits and in but few instances was it necessary to re-run a main traverse line. Under favorable conditions, 100 to 150 acres were covered in a day by a single field party. In rugged wooded country the progress was much less, being at rates of from 5 to 10 acres daily.

Methods of Manufacture of Vitrified Earthenware Products.

BY L. H. EHRLER, ASSOC. M. AM. SOC. C. E.*

The use of vitrified earthenware products, such as electrical conduits, both multiple and single duct, sewer tile, wall copings, flue linings, etc., is universal. The clay which constitutes the material used in the construction of these products is usually a very compact, heavy, bluish earth and has an appearance of having been finely ground by nature. This kind of clay has been found in various parts of the country, but differs in places as regards its consistency. In many places it can be removed very easily by simply spading, while in other localities it must be mined. In the latter case, in order to prepare it for moulding, it must be artificially ground. As to the depths of the seams, it has been found generally to run as thick as 30 ft., and is frequently found very close to the surface. Where it is mined, it has been necessary to go to as great a depth as 100 ft. Where the clay runs quite close to the surface bed, a steam shovel is frequently used to advantage for excavating it and loading cars, which are then run into the factory where hundreds of tons are stored under roof to keep it from the attacks of the weather, as too much water interferes with the moulding, and freezing destroys the adhesiveness. This material, if not far distant, is hauled from the storage house in wheelbarrows to a hopper which thoroughly grinds the clay and properly mixes it with the sand and "grog," which is introduced at this point, besides a sufficient quantity of water which is added to give it the proper plastic effect. About two shovels of ordinary bank sand and an equal amount of finely ground clay pipe previously condemned, so-called "grog," is added to give proper firmness to the product before it reaches the kiln. Some clays, however, do not require the introduction of sand and "grog" as an aid in giving firmness to the product on account of their possessing this element sufficiently. From this point, the mixture finds its way to the die where the earthenware is given its proper shape and dimensions. There are two general methods which obtain. One commonly known as the screw method and the other the steam-pressed method. The first mentioned or screw method propels the mixture by means of a long worm like machine placed horizontally and as the material is being continually fed in, it is thus carried along and [illegible] into a cylindrical box at the end of which is a die provided with [illegible] necessary to form the finished product. By this method [illegible] continuous operation and the proper lengths are [illegible] which moves [illegible] an operator. At this [illegible] of the finished products are [illegible]. This is done by placing [illegible] the die, which leaves [illegible] the plastic material.

Electrical conduits which are frequently provided with dowel pin holes are [illegible] here, the die being provided with the necessary cutting, giving the proper shape and dimensions.

Referring to the steam-pressed method, the mixture is carried from the hopper to a likewise cylindrical box placed vertically, however, instead of horizontally, and the material reaches this box by means of steam pressure instead of the wormlike action of the screw process. The dies in both cases are similar and of course interchangeable.

The bevelling of the ends is done by a special knife provided for that purpose. Transverse combings, where required, are also applied by hand, this being done by means of a steel comb provided with teeth of proper size and spacing. The product as it leaves the die is set vertically on separate plates and thus transferred to a cart which, when the load is made up, is wheeled to the drying room where the pieces are kept about three days. The temperature of the drying room averages 80° F. and is kept very dry. Before the drying room is reached the green product is already in a condition to enable handling without danger of crumbling to pieces, but after it is thoroughly dried it can be handled with less caution and without need of alarm. Great care in handling, however, is always necessary, inasmuch as cracks may appear which would not add to the strength of the finished product. From this point the pieces are wheeled on the same cars to the kiln, where each individual piece is provided with a so-called set ring made up of the very same material but of very short length, usually about 3 ins. The object of this ring is to take the weight of the pipe while it is being burned, besides any undue contraction from the effect of burning. The degree of temperature of a kiln after it has gotten well under way reaches [illegible] F. As to the length of the products, they are seldom manufactured more than [illegible] ins. in length and more generally [illegible] ft. in length, which is especially true of the electrical conduits consisting of multiple ducts of four ways or more. The single duct and the two or three-duct multiples are of 18 ins. and 24 ins., respectively, owing to their becoming warped when molded, as they have not sufficient body to withstand their own weight when being dried and burned.

The pieces are always placed vertically in the kiln to the height of about 8 or 10 ft., which is usually the height of the kiln. The shape of the kiln is circular with a dome-like roof built of brick and provided with from 8 to 12 [illegible] placed regularly about the circumference and near the bottom. The floor of the kiln is provided with [illegible] and the [illegible].

The green earthenware [illegible] is placed [illegible] over these openings and [illegible] are vertically placed [illegible] giving [illegible] each individual piece. The [illegible]

[illegible]

[illegible] It is considered that [illegible] No [illegible] is necessary to prepare the glazing [illegible] over the hot coals [illegible] it and [illegible] through the various [illegible] were and then leaving a glaze [illegible] all the surfaces [illegible] contact. This [illegible] about 24 hours [illegible] The degree of glazing [illegible]. After the product has received [illegible] cause the material to crumble [illegible] but very slowly [illegible] left to cool and when [illegible] temperature is removed [illegible]. The product is [illegible] and conveyed to the [illegible]. Each piece [illegible] "O. K." on the [illegible] material [illegible] cars.

In preparing [illegible] it is essential that the pieces when placed in the cars do not come in contact with each other. To [illegible] are placed between the various layers. This is particularly true of the products of the smaller sizes. In large sewer tile, however, [illegible] avoid [illegible] in the car, which [illegible] great weight. As the [illegible] held responsible [illegible] generally observed.

Methods and Costs; Some Old, and Some New.

[illegible] the Pennsylvania [illegible] Society of Civil Engineers, April [illegible] Mr. [illegible]

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*Engineer Subway Construction, New York Telephone Co., New York, N. Y.

States" type, usually in 6-ft. lengths, that is, sufficiently long to reach about 2 ft. below the sub-grade of the adjacent excavation, were set up and driven to full depth; after which the pits were mucked out to within a foot of their bottom and filled with concrete, the processes of excavation and concreting being carried on without unwatering the pile pit. The result of this was that there was no influx of sand under the piling, as would have been the case had the pit been unwatered without having driven the piling to a much greater depth below excavation. As soon as the concrete in the pile pit had set sufficiently, the remainder of the pit was filled with concrete or bracing, and the work of underpinning was completed in the usual manner. It is interesting to note that in many of these footings, which were nothing more than large square piles of from 1 to 2 ft. penetration, there was never any evidence of settlement, although they were at times subjected to a pressure of as much as 25 tons per sq. ft., with the adjacent material excavated to within at least 18 in. of the toe of the steel piling.

Strength of Pipe Joint of Concrete.—In building an inverted siphon over a new river channel 24-in. heavy cast iron water pipe was used with four 45-degree elbows to turn the pipe from the land level down to the bed of the river and back up again. The joints were all packed with concrete and held the water perfectly. Later a great flood came in the river and washed out the filling under one of the pipes and at an elbow at one end. The 12-ft. length of pipe weighed 2,500 lbs. and the 4-ft. elbow weighed 1,000 lbs. The concrete in those two joints held the weight of 3,500 lbs. for some months until it was convenient to fix it up.

Cost of a Concrete Water Cushion for a Weir.—In connection with the repairing of a concrete weir which had been undermined by a flood a water cushion was constructed to prevent the erosion of the ground by the water flowing over the weir. The water cushion was 1,150 ft. long, 12 ft. deep, with a lip 3 ft. high, into which the water drops and forms a cushion. The cushion was constructed of reinforced concrete, its cost being as follows:

	Total.	Per cu.yd. concrete.
Form work	$ 917	$0.940
Form material	641	.660
Steel work (reinforcement)	327	.385
Steel material	1,617	1.660
Mixing and placing concrete	1,094	1.115
Cement	2,952	3.040
Gravel	1,600	1.650
Total	$9,148	$9.450

The total amount of concrete was 967¾ cu. yds., and the total amount of steel used was 61,549 lbs. Cement cost about $1.27 per barrel, and gravel cost about $1.25 per cubic yard. Common labor was about $2.50 per day of eight hours.

Handling Concrete for an 8-Story Building.—In constructing an 8-story and basement office building of reinforced concrete, the following method was used in handling the concrete: A tower was erected up one side of which the hoist track was placed and on a platform some 30 ft. above the work on the building was a hopper having a capacity of two or three batches of concrete. The tower, track and hopper were elevated as the work progressed story by story. From the hopper, controlled by a gate, the concrete was run into a 7-in. galvanized iron pipe of movable sections and one or more ball-bearing joints, and delivered on the work where desired. At first some difficulty was experienced in securing the right sized pipe, but it was found that a 7-in. pipe was about right. By running a little water in the pipe before starting and afterwards to clean it out, little or no trouble was had. This gravity system proved very satisfactory both in reducing the labor force and also in doing away with the running over the form work and the newly deposited concrete by a large force of laborers. It also gave a concrete of very uniform consistency, in that if too dry it would choke up the pipe and if too wet the aggregate would separate.

Personals.

Mr. Robert H. Richards, professor of mining and metallurgy in the Massachusetts Institute of Technology, is devoting several weeks to professional work in and about Denver, Colo.

At a meeting of the Engineers' Club of Cincinnati on June 17, Mr. A. Elliott Kimberley, of Columbus, O., Special Assistant Engineer of the Ohio State Board of Health, delivered a lecture on "Sewage Purification."

Mr. John E. Ericson, for the past 12 years City Engineer of Chicago, Ill., has been knighted with the order of Vasa by King Gustaf V. of Sweden. Mr. Ericson was born in Sweden, but has resided in Chicago for 28 years.

Mr. Wm. H. Mader has resigned as superintendent of the property of the Pioneer lease, Rhyolite, Nev., and will again enter the service of the Devereaux Engineering Co., New York City. H. F. Callett, mining engineer, who has been operating in British Columbia, will succeed him.

Mr. Charles H. Fitch has resigned his position as Engineer and Executive Officer of the U. S. Reclamation Service and will become identified with an important irrigation development in the State of Idaho. Mr. Fitch has been identified with many important features of the work of the U. S. Reclamation Service since its organization, and rendered valuable service to the Government in many capacities along the lines of its technical work. As topographer in the Geological Survey, as chief of the surveying division of the General Land Office, as head of the public land surveys of Indian Territory, as hydrographer in the Geological Survey, and as engineer in the Reclamation Service, his work has been of great value in various lines of surveying, engineering and administration.

The U. S. Civil Service Commission will receive applications until July 21 for consideration in connection with filling vacancies in the position of designer of bridges and buildings of steel and reinforced concrete, in the Philippine Service, at a salary of $1,800 to $2,000 per annum, according to qualifications. For this position not less than four years' experience in responsible positions is requisite (three years if the applicant is a technical school graduate), of which at least one year must have been in the class of work above specified. No educational examination will be given for this position, but applicants will be required to file forms setting forth their general and technical education, their general experience and their experience in the special line of work called for, and a technical description of some important engineering work upon which they have been employed. Applicants should at once apply to the United States Civil Service Commission, Washington, D. C., for applications forms 2 and 375.

Henry F. Baldwin, Chief Engineer of the Oregon & Washington R. R., a Harriman line, died recently at his home in Seattle, Wash. Mr. Baldwin was born at Waterbury, Md., in 1862 and was graduated from Massachusetts Institute of Technology in the class of 1884. He then entered the service of the Louisville & Nashville R. R. as a rodman, and he remained with that road until 1889, at which time he had been advanced to the position of roadmaster. From 1889 to 1890 he was a division roadmaster for the New York, Lake Erie & Western R. R., and, in the latter year, he became Chief Engineer of the Chicago & Eastern Illinois R. R. In May, 1894, he became Chief Engineer of the Chicago, Peoria & St. Louis Ry. Subsequently he was Engineer of Maintenance of Way of the Erie R. R. at Jersey City, N. J., from 1895 to 1900, and Chief Engineer of the Chicago & Alton Ry. from 1900 to 1904. In January, 1904, he gave up railway work to become Vice-President and General Manager of the Du Pont Powder Co. He resigned this position about two years ago to take up railroad work at Seattle.

Catalogs Worth Having.

Engineers and contractors should have on file the latest catalogs of machines, tools and supplies that they use. In sending for catalogs reviewed or advertised in this paper, you will confer a favor on us if you will write direct to the advertisers and state that you saw the catalog mentioned in ENGINEERING-CONTRACTING. If you are in the market for tools, machinery or supplies, tell us and we will notify promptly the leading manufacturers.

No. 1297. **Portland Cement.**—Marquette Cement Manufacturing Co., Chicago, Ill.

Two pamphlets issued by the above named company giving very handsome views of the new $20,000,000 terminal of the Chicago & Northwestern Ry., and of the new 196x200 ft. 20-story building at Chicago of the People's Gas Light and Coke Co., in the construction of which Marquette cement is being used.

No. 1298. **Buyers' Guide.**—H. O. Conklin Equipment Co., Harvey, Ill.

This pamphlet lists the new and second contractors' machinery for sale by this company giving prices, terms and concise descriptions. This is a very handy list for contractors to have on file.

No. 1299. **Ransome Mixer.**—Ransome Concrete Machinery Co., Dunellen, N. J.

This 36-page pamphlet gives the salient facts in the development, patent protection and construction of the Ransome mixer with tables of sizes, dimensions, etc.

No. 1300. **The Home of Good Paint.**—Detroit Graphite Co., Detroit, Mich.

This is a handsomely printed pamphlet explaining briefly the facilities which the Detroit Graphite Company enjoy and possess for the manufacture of good paint; also describing the extreme care that is exercised in the preparation of every gallon of its product.

No. 1301. **Marsh Pumping Machinery.**—American Steam Pump Co., Battle Creek, Mich.

This is a very good catalog of 136 pages. Each class of pumps is described, its operation is explained and its details illustrated. Full tables of dimensions, capacities, etc., are given. The lists and detail tables have been arranged with care, and in convenient form for reference and comparison. The various lines cover sizes and combinations to meet ordinary requirements, from which a suitable selection may be readily made.

No. 1302. **Diesel Engines.**—Adolphus Busch Purchaser American Diesel Engine Co., South Side Bank Building, St. Louis, Mo.

This is a useful catalog. The development, theory, operation and construction of the engines are described and illustrated. Engineers interested in gas power should secure this pamphlet.

No. 1303. **Tubular Method of Reinforced Concrete Construction.**—Concrete Column & Construction Co., Detroit, Mich.

This pamphlet describes and illustrates an unique and interesting method of reinforced concrete building construction of separately molded members. The pamphlet says: "Herein are indicated a few of the results derived from an exhaustive study of the problem, or rather several of the problems that confront those who would employ concrete in the construction of buildings. Five years of systematic development and practical test have demonstrated that the principles upon which the tubular method is based are correct. Reduced to practice it accomplishes the erection of reinforced concrete buildings without elaborate falsework, and so greatly does it facilitate the several tasks of the builder that even the largest structures may now be erected at a speed that must satisfy the most impatient. In supplanting the wooden forms, concrete itself is made to take the place of wood, and when fresh concrete is poured in, it adheres to the rough inner surface of the tube or shell, and the column or beam is complete. There is no waiting, and nothing to remove, and in the most advanced applications of the method, nothing to add, since the final finish, whether rough, polished, inlaid or veneered, has been applied at the factory."

No. 1304. **Recording Gage.** — The Bristol Co., Waterbury, Conn.

Illustrates various types of gages for recording all commercial ranges of pressure and vacuum.

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